SHIPPING REGISTER OF UKRAINE

RULES

FOR THE CLASSIFICATION AND CONSTRUCTION OF SEA-GOING SHIPS

Volume

4

Kyiv 2020

Shipping Register of Ukraine.
Rules for the Classification and Construction of Sea-Going Ships. Volume 4

This is an edition of the Rules for the Classification and Construction of Sea-Going Ships prepared on the basis of their third edition of 2011, taking into account the changes and additions included in the Bulletins of Amendments and Additions No. 1 (2014.), No. 2 (2016.), No. 3 (2017.), No. 4 (2019r.) and taking into account changes in the applicable international conventions and codes adopted by the relevant resolutions of the International Maritime Organization (IMO), the unified requirements and recommendations of the International Association of Classification Societies (IACS) and changes in the applicable resolutions of the United Nations Economic Commission for Europe and European Parliament and Council directives, changes and additions adopted based on the analysis of the Rules of other classification societies, as well as from the experience of their application (for more details, see Introduction).

The fourth volume contains the following parts:
XI «Electrical equipment»;
XIII «Materials»;
XIV «Welding»;
XV «Automation».

The Rules for the classification and construction of sea-going ships of the Shipping Register of Ukraine have been approved in accordance with the current regulation and come into force on 01.01.2020.

The rules are published in Ukrainian and English. In case of divergence between the Ukrainian and English texts and any doubt as to the interpretation of the Rules, the Ukrainian text shall prevail.

Official edition
of the Shipping Register of Ukraine

Registration of amendments and additions

Letter of change	Bulletin of amendments and additions / Circular letter	Date	Signature
1	**2**	**3**	**4**

Introduction

This edition of the Rules for the Classification and Construction of Sea-Going Ships 2020, compared to their 2011 edition as amended by bulletins, contains the following amendments and additions.

PART XI. ELECTRICAL EQUIPMENT

1. According to the text of the requirements in the part the references to ISO standards have been replaced by references to DSTU standards (effective as of 01.05.2019) with the admission of the relevant ISO and EN standards.

2. Chapter **1**:

para **1.2** has been completed with the deefinitions:

«**1.2.20** Electric power plant (EPP) with variable frequency of the main source of power»;

«**1.2.29** Ship intended for operation at low temperature»;

para **1.3** has been completed with **1.3.3.4** regarding the supervision of the manufacture of electrical equipment of ships intended for long-term operation at low temperatures.

3. Chapter **7**: has been completed with **7.23.5** fuel system ventilation control systems when using natural gas as a fuel, taking into account IACS UI GF 15 (July 2018).

4. Chapter **8**:

para **8.7.2** explanations have been specified;

para **8.8** has been completed with **8.8.4**.

5. Chapter **9**: para **9.2.1** has been given in accordance with Regulation II-1 / 43.1.2 of the SOLAS 74.

6. Chapter **13**: para **13.3.1** explanations have been specified.

7. Chapter **14**: para **14.1.3.2** explanations have been specified.

8. Chapter **17**:

para **17.3** has been completed with **17.3.8**;

requirements **17.7.2.4** regarding the protection of bearings against currents are set out in accordance with **10.3.4**;

para **17.11** has been completed with **17.11.6**;

para **17.12** requirements of para **17.12.3.2** have been specified;

para **17.14** has been completed with **17.14.6** with the requirement for power supply of MPP control systems.

9. Chapter 18:

Table 18.2.3.1 has been amended;

para **18.3** requirements of para **18.3.4.5** have been specified**.**

10. Chapter **20:** requirements of para **20.4.1** have been specified.

11. Chapter **22**:

para **22.4** has been completed with **22.4.3** with requirements for protection of capacitors in CPS with distribution of electric energy of a direct current;

has been completed with **22.8** with requirements for MPP using direct current.

1**2.** The part is supplemented with new Chapters of the following content:

«**23**. Requirements for electrical equipment of ships that use natural gas as fuel»;

«**24**. Special requirements for valve generator sets»;

«**25**. Requirements for electrical equipment of ships intended for operation at low temperatures».

13. Editorial emendments have been made.

PART XV. AUTOMATION

1. According to the text of the requirements in the part references to ISO standards have been replaced by references to DSTU standards (effective as of 01.05.2019) with the admission of the relevant ISO and EN standards.

2. Chapter **1**: para **1.2** has been supplemented by the definition «FMEA».

3. Chapter 3: para **3.1.2** has been amended.

4. Chapter 4:

Tables 4.2.10-1 and 4.2.10-2 have been amended taking into account IACS UR M35 (Rev.8 Jan 2019);

para **4.3.10** has been amended taking into account IACS UI SC 283 (Aug 2017);

Table 4.4.6-2 has been amended taking into account IACS UR M36 (Rev.6 Dec 2018);

para **4.11.1** has been amended regarding the alarm in engineers acommodation.

5. Chapter 6: Table 6.1.3 has been amended.

6. Chapter 8: para **8.9.3** has been amended.

PART XIII. MATERIALS

1. According to the text of the requirements in the part references to ISO standards have been replaced by references to DSTU standards (effective as of 01.05.2019) with the admission of the relevant ISO and EN standards.

2. Chapter **2**:

para **2.2.10.3** requirements for sampling of additional tests of the base metal for structures operating at low temperatures has been specified;

paras **2.5.1.6**, **2.5.5** requirements for ice-resistant coating tests have been specified;

para **2.5.7** has been revised taking into account the analysis of the Rules of other classification societies;

has been completed with **2.6** with requirements for tests primes not removed before welding

3. Chapter **3**:

has been completed with **3.2.6.5** taking into account IACS UR W11 (Rev.9 May 2017);

para **3.2** para **3.2.3** has been amended, requirements of **3.2.8.1**, **3.2.8.3** have been specified, Table 3.2.8.3 has been amended;

para **3.3** paras **3.3.1.1** and **3.3.1.2** have been amended;

para **3.4** paras **3.4.1.1** and **3.4.1.2** have been amended;

para **3.9** para **3.9.1.5** has been canceled, paras **3.9.1.6** and **3.9.1.7** have been renumbered into **3.9.1.5** and **3.9.1.6**;

para **3.10** paras **3.10.1.1** and **3.10.1.5** have been amended;

para **3.11** para **3.11.2** has been amended;

para **3.12** para **3.12.9.5.1** has been amended;

para **3.15** requirements of **3.15.2.1** have been specified;

para **3.17** para **3.17.1.2** has been amended;

para **3.18** para **3.18.17** has been amended.

4. Розділ **5**:

para **5.1** para **5.1.7** has been amended;

para **5.3** paras **5.3.1.6** and **5.3.4.2** have been amended.

5. Chapter **6**: Table 6.5.3.1 has been amended in terms of requirements for tests of ice-resistant coatings, taking into account practical experience.

6. Chapter **7**:

paras **7.2.1.2**, **7.2.4.2**, **7.2.4.2.4** and **7.2.4.5.3** have been amended.

7. Chapter **8**:

paras **8.1.2**, **8.2.2**, **8.4.2.5**, **8.4.2.6** and **38.1.1** have been amended;

para **8.1** has been completed with **8.1.3.3.5**.

8. Chapter **9** has been completed with **9.6** on the basis of practical experience of technical supervision over the production of layered composite material "titanium steel".

9. Chapter **10**:

para **10.3** in para **10.3.2.1** requirements for plywood has been specified.

10. Hasd been completed with the new Chapter:

«11. Materials used for ships intended for operation in low temperature conditions».

11. Editorial emendments have been made.

PART XIV. WELDING

1. According to the text of the requirements in the part references to ISO standards have been replaced by references to DSTU standards (effective as of 01.05.2019) with the admission of the relevant ISO and EN standards.

2. Chapter **1**:

para **1.1.3** has been amended;

para **1.2.1** explanations have been specified;

3. Chapter **2**:

In para **2.1.9** the reference to the Collection of normative and methodical materials of the Register of the USSR (book four) is replaced by the reference to **6.5.4.3**, part XIII "Materials";

Table 2.2.4 has been completed;

para **2.2.5** and Tables 2.2.5-1 and 2.2.5-2 have been completed with new categories of welding materials and requirements for welding of high-strength steel structures taking into account IACS UR UR W23 (Rev.2 Apr 2018);

Tables 2.2.7.1-1 and 2.2.7.1-2 have been renumbered into 2.2.7-1 and 2.2.7-2 and amended;

paras **2.8.1, 2.12.1, 2.13.15** have been amended.

4. Chapter **3**:

paras **3.1.2.2.1** (the last abstruct), **3.1.3.3** and Table 3.1.1.2-2 have been amended;

para **3.1.6** has been issued a separate para **3.2**;

paras **3.2, 3.3, 3.4** have been renumbered into **3.3, 3.4, 3.5**;

para **3.2.5.15** (Note), **3.5.4.1** and Tables 3.2.5.14-2, 3.2.5.14-3, 3.4.1.2 (Footnote 2) have been amended;

5. Chapter **4**:

paras **4.1.3.3, 4.1.5.1, 4.1.5.4** (Note), **4.1.7.1, 4.1.8.2, 4.1.8.6, 4.1.8.8, 4.2.1.2**, **4.5.4.1**, **4.8.3.2**, Fig. 4.2.2.1, Fig. 4.8.4.2 and Tables 4.2.4.4-2, 4.2.4.4-3, 4.3.1.1, 4.5.1.3.2, 4.8.1.4-2 (for A-7ss), have been amended:

Table 4.1.2.3 new categories of welding materials for welding high strength steel structures have been added taking into account IACS UR W23 (Rev.2 Apr 2018);

para **4.2.3.1** new categories of welding consumables for tests to determine the content of diffusion hydrogen in the weld material have been added taking into account IACS UR W23 (Rev.2 Apr 2018);

Tables 4.3.1.1, 4.4.1.4 and 4.5.2.1 Fig. 4.3.2.1, Fig. 4.4.2.2.1, Fig. 4.6.2.3 – 1 the symbol of the longitudinal cylindrical specimens for tensile testing TL has been rplaced by LT taking into account IACS UR W17 (Rev.5 Mar 2018);

para: **4.9** has been marked as **4.6**, **4.6** – as **4.7**, **4.7** – as **4.9;**

paras **4.6.1.1**, **4.10.1.2**, **4.10.1.4**, **4.10.2** and Tables 4.9.1.3-1, 4.9.1.3-2, 4.9.1.4, 4.9.3.6 have been amended;

para **4.6.1.2** the new category of welding materials 5Y40 for welding of steels of the increased durability has been added taking into account IACS UR W17 (Rev.5 Mar 2018);

para **4.7.1.1** requirements for the state of supply of high-strength steels have been specified taking into account IACS UR W23 (Rev.2 Apr 2018);

para **4.7.1.3** new categories of welding materials Y89 and Y96 for welding of high-strength steels have been added taking into account IACS UR W23 (Rev.2 Apr 2018);

Table 4.7.2.4 new categories of welding materials Y89 and Y96 for welding of high-strength steels have been added taking into account IACS UR W23 (Rev.2 Apr 2018);

para **4.7.3.1** requirements for the base metal for the manufacture of samples for testing butt welds have been specified taking into account IACS UR W17 (Rev.5 Mar 2018);

Table 4.7.3.3 new categories of welding materials Y89 and Y96 for welding of high-strength steels have been added taking into account IACS UR W23 (Rev.2 Apr 2018);

Table 4.7.4.2 new categories of welding materials Y89 and Y96 for welding of high-strength steels have been added taking into account IACS UR W23 (Rev.2 Apr 2018);

para **4.7.5** new requirements to tests of welding materials Y89 and Y96 for welding of high-strength steels have been added taking into account IACS UR UR W23 (Rev.2 Apr 2018);

6. Chapter **5** «Approval tests for welders» has been revised with general provisions and replacement of requirements with reference to national and / or international standards and requirements of **4**, Part **3** "Technical supervision of the manufacture of materials" of the Rules for technical supervision of the construction of ships and the manufacture of materials and products.

7. Chapter **6** «Approval of welding procedures for welding of steel structures and products» has been revised with general provisions and replacement of requirements with reference to national and / or international standards and requirements of **6**, Part 3 "Technical supervision of the manufacture of materials" of the Rules for technical supervision of the construction of ships and the manufacture of materials and products.

8. Chapter **7** «Approval of welding procedures for aluminium alloys» has been revised with general provisions and replacement of requirements with reference to national and / or international standards and requirements of **7**, Part **3** "Technical supervision of the manufacture of materials" of the Rules for technical supervision of the construction of ships and the manufacture of materials and products.

9. Chapter **8** para **8.1.1** has been amended.

10. Editorial emendments have been made.

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PART XI. ELECTRICAL EQUIPMENT

1. GENERAL

1.1 APPLICATION

1.1.1 The requirements of this Part of the Rules apply to electrical installations in ships subject to the Register survey, as well as to individual types of electrical equipment in accordance with **1.3**.

1.1.2 It is recommended that the relevant requirements of this Part shall be also applied to electrical equipment, which is installed in ships not specified in **1.3.2** and **1.3.3**.

1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of the Rules are given in Part I "Classification"[1] of the Rules.

For the purpose of this Part the following definitions and explanations have been adopted:

1.2.1 *Emergency source of electrical power* is a source of electrical power intended to supply necessary ship's services in case of power failure on the main switchboard.

1.2.2 *Emergency lighting* is lighting of ship's spaces and zones by means of lighting fixtures fed from the emergency source of power or from the transitional emergency source of power.

1.2.3 *Emergency transitional source of electrical power* is a source of electrical power intended to supply necessary ship's services from the moment of the power failure on the main switchboard busbars until the emergency generator is switched on to supply the emergency switchboard busbars.

1.2.4 *Emer gency switchboard* is a switchboard intended to be supplied directly from the emergency or emergency transitional source of electrical power in case of failure of the main source of electrical power and to supply the emergency services.

1.2.5 *Emergency consumers* are consumers which shall be supplied by an emergency source of electrical power if there is a failure of the main electrical power source.

1.2.6 *Antistatic earthing* is electrical connection to ensure grading of static electricity potentials of the structural parts of equipment and ship's hull due to their direct contact or through antistatic earthing conductors.

The antistatic earthing conductors are:

metal conductors connecting equipment subject to antistatic earthing, cable shields, piping, etc, to one another and/or to ship's hull or other equipment earthed;

layers of conductive substances applied onto equipment surfaces, such as: metal coatings, conductive plastics, compounds, mastics, antistatic paint coatings, etc.

1.2.7 *Safety voltage* is any voltage not dangerous to the personnel.

This condition is considered to be satisfied if the windings of transformers, converters, and other devices to step down voltage are electrically separated and if the value of stepped-down voltage across these devices or sources of electrical power does not exceed:

50 V between poles for direct current;

50 V between phases or between phases and the ship's hull for alternating current.

1.2.8 *Air termination network* is the upper part of the lightning protection device intended for the perception of atmospherics.

1.2.9 *Not readily ignitable electrically insulating material* is a material, which sustaines the tests specified in the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

1.2.10 *Shaft generators* are generators driven by the main machinery and supplying the ship's mains or separate consumers.

1.2.11 *Down conductor* is a conductor, which electrically connects the air termination network to the earth termination network.

1.2.12 *Essential services* are services normal operation whereof ensures safe navigation, safety of human life and safety of cargo on board ship; essential services are divided into primary and secondary services.

.1 *Primary essential services* are the services, which need to be in continuous operation to maintain propulsion and steering of the ship. Such services are those listed in **1.3.2.1**.

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[1] Hereinafter – refered to as I «Classification».

.2 *Secondary essential services* are the services, which need not necessarily be in continuous operation to maintain propulsion and steering but which are necessary for maintaining the ship safety. These services shall be ready for the immediate activation. Such services are those listed in **1.3.2.2**.

1.2.13 *Galvanic intrinsic safety* is such a state of the ship equipment and systems, under which the possibility of fire or explosion due to electric sparking in case of galvanic contact of the ship with a shore structure or another ship caused by electrochemical phenomena and stray currents in surrounding sea water and ground is excluded.

1.2.14 *Main switchboard* is a switchboard intended to be supplied directly from the main source of electrical power and to supply the ship services.

1.2.15 *Uninterruptible power system (UPS)* is combination of converters (rectifier-inverter), switches (bypass) and energy storage means, for example, batteries, constituting a power system for maintaining continuity of load power in case of input power failure.

1.2.16 *Electrical network* is a set of all interconnected installations with an equal rated voltage.

1.2.17 *Electrical installation o f low power* is an electrical installation of a ship with the total power of supply sources up to 50 kW (kVA).

1.2.18 *Electrostatic intrinsic safety* is such a state of the ship equipment and systems, under which the possibility of fire or explosion due to static electricity discharges is excluded.

1.2.19 *Electric power plant (EEU)* is a set of ship electrical equipment, combined with the process of generation, distribution and conversion of electrical energy into other types of energy (mechanical, thermal, light, chemical, etc.).

1.2.20 *Electrical power plant with variable frequency main power source* is an electrical power plant intended for operation in a set frequency range.

1.2.21 *Earthing* is electrical connection of a part of electrical equipment to be earthed to ship's hull.

1.2.22 *Lightning protection zone* is the area, within the limits of which the ship's space is protected against direct lightning strokes.

1.2.23 *Competent body* is an organization possessing appropriate knowledge and experience in a specific area, which documents are recognized by the Register.

1.2.24 *Ship's hull* means all ship's metal parts, which have a reliable electrical connection to the outer metal shell plating. For ships with non-conducting hull, it is a special copper sheet with the area of not less than 0,5 m^2 and the thickness not less than 2 mm, which is fixed to the outside of the ship's shell plating at a level below the light load waterline and is used for earthing all the equipment installed on board the ship.

1.2.25 *Non-essential services* are services, the temporary disconnection of which does not impair the safety of navigation, the safety of human life and the safety of cargo on board.

1.2.26 *Main electrical power source* is a source of electrical power intended to supply all electrical equipment and systems essential for maintaining the ship in normal operational and habitable condition, without resorting to the emergency source of electrical power.

1.2.27 *Main electrical power plant* is a space where the main source of electrical power is placed.

1.2.28 *Special electrical spaces* are spaces or locations intended expressly for electrical equipment and accessible only to operating personnel.

1.2.29 *Ship intended for operation at low temperatures* means a ship intended for voyages in areas or through areas where the average daily sub-zero temperature is less than -10°C.

1.3 SCOPE OF SURVEYS

1.3.1 General.

General provisions applicable to the classification procedure, survey during ship's construction and manufacture of the equipment are stated in the General Regulations for the Classification and Other Activity and in Part I "Classification".

1.3.2 Survey of ship's electrical equipment.

Main and emergency sources of electrical power, power and lighting transformers and converters (both rotating and static), main and other switchboards, cable network, as well as electrical equipment, systems and arrangements listed in **1.3.2.1** to **1.3.2.4** are subject to survey on board the ship.

1.3.2.1 *Primary essential services are:*

.1 steering gear;

.2 pumps of hydraulic systems of CP-propellers;

.3 scavenging air blower, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and cooling water pumps for main and auxiliary engines and turbines necessary for propulsion;

.4 forced draught fans, feed water pumps, water circulating pumps, vacuum pumps and condensate pumps for steam plants on steam turbine ships, and also for auxiliary boilers on ships where steam is used for equipment supplying primary essential services;

.5 oil burning installations for steam plants on steam turbine ships and for auxiliary boilers where steam is used for equipment supplying primary essential services;

.6 electrical equipment for azimuth thrusters which are the sole means for propulsion/steering with lubricating oil pumps, cooling water pumps;

.7 electrical equipment for electric propulsion plant and azimuth electric propulsion plant with lubricating oil pumps, cooling water pumps and forced draught systems:

.8 electric generators and associated power sources supplying the equipment specified in **1.3.2.1.1 − 1.3.2.1.7**;

.9 hydraulic pumps supplying the equipment specified in **1.3.2.1.1 − 1.3.2.1.8**;

.10 viscosity control equipment for heavy fuel oil;

.11 navigation lights, aids and signals;

.12 internal communication devices/systems;

.13 lighting system;

.14 control, monitoring, alarm and safety devices/systems for equipment to primary essential services;

.15 other primary essential services needed to ensure that the ship is used in compliance with its purpose and class notation.

1.3.2.2 *Secondary essential services are:*

.1 windlass;

.2 fuel oil transfer pumps and fuel oil treatment equipment;

.3 lubrication oil transfer pumps and lubrication oil treatment equipment;

.4 pre-heaters for heavy fuel oil;

.5 starting air and control air compressors;

.6 bilge, ballast and heeling pumps;

.7 fire pumps and other fire extinguishing medium pumps;

.8 ventilating fans for engine and boiler rooms;

.9 services considered necessary to maintain dangerous spaces in a safe condition, including services for hull earthing on oil tankers, lightning protection and services ensuring electrostatic and galvanic intrinsic safety;

.10 fire alarm systems;

.11 electrical equipment for watertight closing appliances;

.12 electric generators and associated power sources supplying the equipment specified in **1.3.2.2.1 – 1.3.2.2.11**;

.13 hydraulic pumps supplying the equipment specified in **1.3.2.2.1 –1.3.2.2.12**;

.14 tunnel and azimuth thrusters;

.15 inert gas devices/systems in oil tankers;

.16 control, monitoring, alarm and safety devices/systems for cargo containment systems;

.17 electric drives for refrigerating plants, specified in **1.1**, Part XII "Refrigerating Plants";

.18 control, monitoring, alarm and safety devices/systems for equipment to secondary essential services;

.19 other secondary essential services needed to ensure that the ship is used in compliance with its purpose and class notation.

1.3.2.3 3 Services for habitability are those services, which need to be in operation for maintaining the vessel's minimum comfort conditions for the crew and passengers.
Examples of equipment for maintaining conditions of habitability are as follows:

.1 cooking;

.2 heating;

.3 domestic refrigeration;

.4 domestic ventilation;

.5 sanitary and fresh water; .6 electric generators and associated power sources supplying equipment specified in **1.3.2.3.1 − 1.3.2.3.5**.

1.3.2.4 Other electrical services are:

.1 electrical equipment of processing machinery of ships used for processing the living resources of the sea and not engaged in their catching (refer to **19.4.4.1**);

.2 electrical equipment of fishing and processing machinery of fishing vessels (refer to **19.10.1.1**);

1.3.2.5 Electrical equipment of domestic services shall be subject to survey on board the ship only in respect to the following:

.1 influence exerted by the operation of this equipment on the quality of electrical power produced by the shipboard electrical power plant;

.2 selection of the types and sections of cables and wires, as well as the methods of cable installation;

.3 insulation resistance, earthing and protective devices.

1.3.3 Survey during manufacture of electrical equipment.

1.3.3.1 The following kinds of electrical equipment intended for use in installations and systems listed in **1.3.2** are subject to survey during manufacture:

.1 generating sets;

.2 electric machines;

.3 transformers;

.4 switchboards;

.5 control and monitoring panels;

.6 electric slip couplings and brakes;

.7 apparatus and devices for electrical protection, starting, control and switching;

.8 apparatus and devices of internal communication and signalling;

.9 power semiconductor converters and other similar power units;

.10 fuel and oil heaters;

.11 accumulator batteries;

.12 cables and wires;

.13 fixed electrical measuring instruments;

.14 electrical apparatus and facilities to measure non-electrical values;

.15 space heating and cooking appliances;

.16 lighting switches and accessories;

.17 stationary lighting fixtures;

.18 control and monitoring devices;

1.3.3.2 The safe type electrical equipment shall be surveyed (with respect to its safety) by a competent authority whose documents are recognized by the Register, irrespective of whether or not this equipment is subject to survey according to the requirements of **1.3.3.1**.

1.3.3.3 Scope of tests of electrical equipment after manufacture and requirements for tests are given in the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

1.3.3.4 All electrical equipment intended for installation on the open decks and in the open unheated spaces shall be tested for cold endurance according to **10.5.4.2**, Part IV "Technical Supervision during Manufacture of Products" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships at the temperature in the chamber being 10°C lower than the design ambient temperature or at the temperature of -40°C (whichever is lower).

The Register certificates issued for electrical equipment to be installed on the open decks and in the open unheated spaces of ships with distinguishing marks **WINTERIZATION(-40)** and **WINTERIZATION(-50)** shall contain an indication whether it is allowed to use it at appropriate design ambient temperature.

1.4 TECHNICAL DOCUMENTATION

1.4.1 General provisions applicable to the procedure of approval of technical documentation scope of technical documentation on electrical equipment for the entire ship to be submitted to the Register for consideration is stated in **4**, Part I «Classification».

1.4.2 Prior to starting the survey of the electrical equipment manufacture, the following documentation shall be submitted to the Register for consideration:

.1 description of the principle of operation and main characteristics;

.2 specification (list of items), which indicates all the components, instruments and materials used and their technical characteristics;

.3 general view drawing with sectional views;

.4 circuit diagram;

.5 programme of tests;

.6 results of rotor shaft (armature) calculation and drawing of fastening of poles, active iron core, commutator, etc., as well as welded joints of the spoke rib and the shaft, for electric machines with rated current in excess of 1000 A;

.7 busbar calculation of electrodynamic and thermal short circuit strength - for switchboards, if rated current of the generators operating separately or total current of the generators operating in parallel exceeds 1000 A;

.8 data concerning immunity to static or dynamic interference or method of electromagnetic compatibility testing;

.9 measures to be taken for interference suppression.

When necessary, the Register may require supplementary technical documentation and data on reliability to be submitted.

2. GENERAL REQUIREMENTS

2.1 OPERATING CONDITIONS

2.1.1 Influence of climatic conditions.

2.1.1.1 Як The rated ambient air and cooling water temperatures for electrical equipment shall be those specified in Table 2.1.1.1.

Table 2.1.1.1

№	Location of equipment	Ambient air and cooling water temperature, °C			
		Unrestricted service		Navigation outside the tropical zone	
		Air	Water	Air	Water
1	Machinery and special electrical spaces, galleys	+45 … 0	+32	+40 … 0	+25
2	Weather decks	+45 … –25	–	+40 … –25	–
3	Other spaces	+40 … 0	–	+40 … 0	–

*Note***.** Electronic elements and devices designed for mounting in the switchboards, panels or casings shall be capable of reliable performance at an ambient air temperature up to 55°C.

Temperature up to 70°C shall not lead to failure of the elements, devices and systems

2.1.1.2 Electrical equipment shall be capable of reliable performance at a relative air humidity of 75 ± 3% and a temperature of +45 ± 2°C or at a relative air humidity 80 ± 3% % and a temperature +40 ± 2°C, as well as at a relative humidity of 95 ± 3% and a temperature of +25 ± 2°C.

2.1.1.3 and a temperature of +35°C, provided:

.**1** the equipment is not for use for emergency services and is located outside the machinery spaces;

.2 temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, the remaining unit is capable of satisfactorily maintaining the design temperature;

.3 the equipment installed in such spaces shall be able to work safely at temperature of +45°C until the nominal working ambient temperature may be achieved; the cooling equipment shall be rated for +45°C ambient temperature;

.4 audible and visual alarms shall be provided at a continually manned control station to indicate any malfunction of the cooling units.

2.1.2 Mechanical effects.

2.1.2.1 Electrical equipment shall be capable of reliable performance at vibrations with frequency of 2 to 80 Hz, i.e. with an amplitude of displacements of ±1 mm for frequency range of 2 to 13,2 Hz and an acceleration of ±0,7 g for frequency range of 13,2 to 80 Hz.

Electrical equipment located on the sources of vibrations (diesel engines, compressors, etc.) or in the steering gear room shall be capable of reliable performance at vibrations of 2 to 100 Hz, i.e. with an amplitude of displacement of ±1,6 mm for frequency range of 2 to 25 Hz and an acceleration of ±4,0 g for frequency range of 25 to 100 Hz.

Electrical equipment shall also be capable of reliable performance at shocks having an acceleration of ±5,0 g and at a frequency of 40 to 80 shocks per minute.

2.1.2.2 Electrical equipment shall be capable of reliable performance with the ship having continuous list up to 15° and trim up to 5°, as well as with the ship rolling up to 22,5° with period of rolling of 7 - 9 s and pitching up to 10°.

Emergency equipment shall also be capable of functioning reliably with the ship having continuous list up to 22,5° and trim up to 10°, or within the same limits of simultaneous list and trim.

In gas carriers and chemical tankers, the emergency electrical power sources shall be capable of reliable performance with the ship having list up to 30°.

2.1.2.3 Electrical equipment shall possess the relevant mechanical strength and shall be so located as to avoid the risk of mechanical damage (refer also to **2.7.4**).

2.1.3 Permissible variations of supply parameters.

2.1.3.1 Electrical equipment shall be so designed that it remains operative in all cases, except as noted in **10.8.2**, **14.1.4.2 - 14.1.4.3** at all variations from the supply voltage and frequency as specified in Table 2.1.3.1 (refer also to **3.1.2.2** and **16.8.3.3**).

Table 2.1.3.1

Parameters		**Variations from rated values**		
		for long periods, %	for short periods	
			%	time, s
Voltage (a.c)	Voltage	+6...–10	±20	1,5
	Frequency (frequency range of an electrical power plant with variable frequency main power source)	±5	±10	5
Voltage (d.c.)	Voltage	±10	5	cyclic variations
			10	ripple

Note. When the services are fed from accumulator battery:
long-period voltage variation within +30 до –25% for the equipment fed from the accumulator battery connected to the charging unit;
long period voltage variation within +20 до –25% for the equipment, which is not connected to the charging unit.

2.1.3.2 On ships of restricted areas of navigation **R3** and **R3-IN**, it is allowed (except for in machinery and devices of essential services) to use the electrical equipment (of general commercial type) not fully complying with the above requirements.

2.2 ELECTROMAGNETIC COMPATIBILITY

2.2.1 General.

2.2.1.1 The present requirements are applicable to electrical equipment and automation equipment to ensure electromagnetic compatibility on board.

2.2.1.2 Failure-free performance of the equipment shall be ensured under conditions of interference having the following parameters:

.1 static and variable (50 Hz) magnetic field in accordance with Table 2.2.1.2.1.

Installation of equipment is permitted:

class 1 - at a distance of 2 m and more from a powerful field source (busbar, group transformer);

class 2 - at a distance of 1 m and more from a powerful field source;

class 3 - irrespective of the distance from field source of any kind;

Table 2.2.1.2.1

Class of equipment	**Intensity, A/m**	
	static field	variable field (50 Hz)
1	100	100
2	400	400
3	1000	1000

.2 harmonic components of voltage in supply circuits in accordance with the higher harmonics diagram for ship mains to be found in Fig. 2.2.1.2.2 on a logarithmic scale;

.3 electrostatic discharges with a voltage amplitude of 8 kV;

.4 radio frequency electromagnetic fields within a range of 80 MHz - 2 GHz with a root-meansquare value of field intensity of 10 V/m;

.5 nanosecond voltage pulse with an amplitude of 2 kV for the power supply and of 1 kV for signalling and control cables with a duration of 5/50 ns;

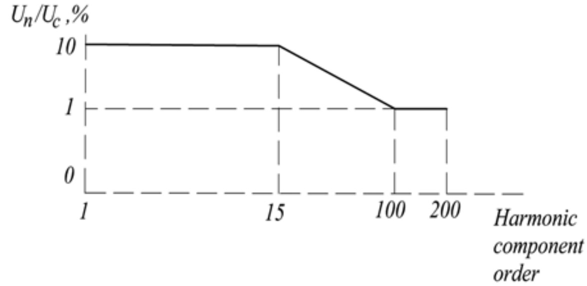


Fig. 2.2.1.2.2 Diagram of higher harmonic components for ship mains

.6 radio frequency interference in conductivity circuits within a range of 150 kHz to 80 MHz with a root-mean-square voltage of 3 V and 80 % modulation at a frequency of 1 kHz;

.7 microsecond voltage pulse with the duration of 1,2/50 µs in supply circuits with an amplitude of 1 kV when fed via the coupling decoupling device between each circuit and casing and of 0,5 kV when fed via the coupling decoupling device between the circuits.

2.2.1.3 The total harmonic distortion shall not exceed 8 % and shall be determined by the formula

$$K_U = \sqrt{\sum_{k=2}^{40} (U_{p,k}/U_{p,1})^2} \cdot 100\ \% \qquad (2.2\quad)$$

where $U_{p,k}$ – mean square value of k harmonic subgroup voltage;
k – harmonic component order.

$$U_{p,k} = \sqrt{U^2 k + \sum_{h=-1}^{h=+1} U^2_{c,k+h}},\ \text{B}, \qquad (2.2.1.3\text{-}2)$$

where U_k – mean square voltage value of k harmonic component;
$U_{c,k+h}$ – mean square value of spectral component adjacent to k harmonic component;
k – spectral component order.

The value of K_U is specified for the complete electrical power system of a ship.

For circuits of electric propulsion plants not directly connected to ship's general consumers the total harmonic distortion shall not exceed 10 %.

Busbars with $K_U > 8\%$ may be used for power supply to powerful sources of voltage curve harmonic components and to electrical equipment not sensitive to such harmonic components, provided that the busbars are connected to the main busbars through isolating devices (refer to **2.2.2.2**).

When the specified value of the total harmonic distortion is exceeded, all electrical equipment shall be designed for such excess, which shall be supported by the documentation.

2.2.1.4 The intensity levels of radio interference from equipment in the power supply circuits shall not exceed the following values within the frequency bands given below:

for the equipment installed on open deck and navigation bridge:
10 - 150 kHz – 96 - 50dB;
150 - 350 kHz – 60 - 50 dB;
350 kHz - 30 MHz – 50 dB,
for the equipment installed in machinery and other enclosed spaces:
10 - 150 kHz – 120 - 69 dB;
150 - 500 kHz – 79 dB;
500 kHz - 30 MHz – 73 dB.

Artificial mains network and quasi-peak measuring receiver shall be used for measuring the intensity level of radio interference.

The receiver bandwidth when measurements are taken within the frequency band from 10 to 150 kHz shall be 200 Hz and within the frequency band from 150 kHz to 30 MHz - 9 kHz.

2.2.1.5 On ships, for which the level of radio interference from power semiconductor converters cannot be limited in conformity with **2.2.1.4**, the mains of automation, radio and navigational equipment shall be galvanically isolated from the mains of those converters so that at least 40 db are damped within the frequency range 0,01 - 30 MHz.

The power supply cables of equipment having the radio interference levels in excess of those stipulated by **2.2.1.4** shall be laid at least 0,2 m away from the cables of other equipment groups where the common cable run is longer than 1 m (refer to **2.2.2.8**).

2.2.1.6 The levels of the radio interference electromagnetic field induced at a distance of 3 m from the equipment shall not exceed the following values within the frequency bands given below: for the equipment installed on open deck and navigation bridge:

150 - 300 kHz - 80 - 52 dB;

300 kHz - 30МГц – 52 - 34 dB;

30 - 2000 MHz – 54 dB, except for the band 156 – 165 MHz, where the level shall be equal to 24 dB;

for the equipment installed in machinery and other enclosed spaces:

150 kHz - 30 MHz – 80 - 50 dB;

30 - 100 MHz – 60 - 54 dB;

100 - 2000 MHz – 54 dB, за виключенням діапазону 156 – 165 MHz, де він повинний бути рівним 24 dB.

Quasi-peak measuring receiver shall be used to take measurements.

The receiver bandwidth within the frequency band from 150 kHz to 30 MHz and from 156 to 165 MHz shall be 9 kHz and within the frequency band from 30 to 156 MHz and from 165 MHz to 1 GHz - 120 kHz.

2.2.2 Measures to ensure electromagnetic compatibility.

2.2.2.1 To ensure protection of radio equipment against electromagnetic interference, the requirements of Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships shall be considered.

2.2.2.2 For the purpose of dividing the power supply of the ship, rotary converters, special transformers and filters shall be used.

2.2.2.3 Power cable screens or metal armour shall be connected to the metal casing of relevant equipment and shall be earthed as frequently as possible, at each end as a minimum.

2.2.2.4 The screens of signal cables shall be earthed at one point on the side of the initial signal processing block. The cable shall have an external insulating sheath.

2.2.2.5 Continuous screening shall be ensured, and for this purpose cable screens shall be connected to equipment casings, and it shall also be ensured in cable branch boxes and cable distribution boxes, and in way of cable penetrations through bulkheads.

2.2.2.6 The earthing installed for the purpose of interference protection shall have an electric resistance not greater than 0,02 Ohm, minimum length possible, shall be resistant to vibration and corrosion, and shall be readily accessible for inspection.

2.2.2.7 Cable screens shall not be used as return conductors.

2.2.2.8 By the type of signals conveyed, ship cables are subdivided in groups as follows:

.1 coaxial cables of radio receivers and conveying video signals with the level of signals 0,1 μV to 500 μV;

.2 screened or coaxial cables conveying analogue or digital signals with a level 0,1 to 115 V;

.3 screened cables of telephone and radio broadcasting apparatus, control and signalling network with the level of signals 0,1 to 115 V;

.4 unscreened and located below the deck or screened and located above the deck cables of power and lighting network with the level of signals 10 to 1000 V;

.5 coaxial or screened cables of the transmitting aerials of radio transmitters, radar installations and echo sounders, power semiconductor converters with the level of signals 10 to 1000 V.

2.2.2.9 Cable of the same group may be laid in the same cable run provided interference-sensitive equipment is not influenced by the difference in the levels of signals conveyed.

Where cable lengths laid in parallel are in excess of 1 m, the cables (cable runs) of different groups shall be laid at least 0,1 m apart and their intersections shall be effected at right angles.

The radar installation and echo sounder cables mentioned in **2.2.2.8.5** shall either be double-screened or, if they are coaxial, laid inside a metal pipe. The outer screen shall be earthed, as well as the principal screen of the cable.

2.2.2.10 When electrical equipment is installed or cables are laid in the vicinity of magnetic compasses and to ensure protection against interference from other navigational equipment, the requirements of Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

2.2.2.11 On all ships constructed from non-conductive materials, for which radio equipment is required by the Rules, all cables located within 9 m from the aerials shall be shielded or otherwise protected from radio interference, and all the equipment on board those ships shall be fitted with devices for radio interference suppression.

2.3 MATERIALS

2.3.1 Structural materials.

2.3.1.1 The structural parts of electrical equipment shall be fabricated of durable materials not containing asbestos, rated at least as having low flame-spread characteristics, resistant to sea air, oil and fuel vapour effects, or reliably protected against such effects.

For equipment installed or intended for use in dangerous spaces and zones, the structural parts of electrical equipment shall be fabricated of materials ensuring electrostatic and galvanic intrinsic safety**.**

2.3.1.2 Screws, nuts, hinges and similar items designed to fasten enclosures of the electrical equipment to be installed on weather decks or in spaces with increased humidity shall be made of corrosion-resistant materials or have effective corrosion-resistant covering.

2.3.1.3 Усі струмоведучі частини електричних пристроїв повинні виготовлятися з міді, мідних сплавів або інших матеріалів, що мають рівноцінні властивості, за винятком:

.1 rheostat elements, which shall be made of mechanically strong materials having high resistivity and capable of withstanding high temperatures;

.2 short-circuit rotor windings of asynchronous and synchronous motors, which may be made of aluminium or its alloys resistant to sea conditions;

.3 carbon brushes, cermet contacts and other similar parts when the properties specified so require;

.4 parts of electrical equipment directly connected to the ship's hull in case of hull-return singlewire system;

.5 aluminium windings of high-voltage transformers in compliance with **18.4.1.6**.

2.3.2 Insulating materials.

2.3.2.1 Insulating materials of live parts shall not contain asbestos and shall have adequate dielectric strength and resistance to creepage currents, moisture and oil, as well as sufficient mechanical strength, or else be suitably protected.

The heating temperature of current-carrying parts and their connections shall not exceed the permissible heating temperature of the insulating materials at the rated load.

2.3.2.2 Non-flammable liquids may be used for cooling uninsulated parts of electrical equipment.

2.3.2.3 The insulating materials used for winding insulation in machines, apparatus and other equipment for essential services shall comply with the agreed standards.

The use of insulating materials not inferior to Class E is recommended.

2.3.2.4 Conductors used in electrical devices for internal connections shall have insulation made of materials rated at least as having low flame-spread characteristics and for apparatus with increased heating and also indicated in Section **15** - of non-combustible materials.

2.3.2.5 For insulation materials used for the manufacture of cables, refer to. **16.3**.

2.4 STRUCTURAL REQUIREMENTS AND PROTECTION OF ELECTRICAL EQUIPMENT

2.4.1 General.

2.4.1.1 Such parts as require replacement while in service shall be easily dismountable.

2.4.1.2 Where screw fastenings are employed, provision shall be made of exclude self-loosening of screws and nuts or, where dismantling and opening are a frequent occurrence, loss of same.

2.4.1.3 Gaskets used in components of electrical equipment (such as doors, covers, sight holes, packing glands, etc.) shall ensure adequate protection when in service.

The gaskets shall be secured to the covers or casings.

2.4.1.4 If the casings, panels and covers of electrical equipment, installed where unspecialized personnel has access to it, render lived parts inaccessible, they shall be opened with tools only.

2.4.1.5 Suitable water drainage arrangements shall be provided in electrical equipment where condensation is likely to occur.

Channels shall be fitted inside the equipment to provide for condensate drainage from all equipment components.

The windings and live parts shall be so arranged or protected that they are not exposed to the effects of such condensate as may accumulate inside the equipment.

2.4.1.6 Electrical equipment with forced ventilation, designed for installation in bottom parts of damp spaces, shall be provided with a ventilation system so as to avoid, as far as possible, suction of moisture and oil vapours inside the equipment.

2.4.1.7 Where measuring instruments with oil, steam or water supply are fitted in the control panel or desk, measures shall be taken to prevent these agents from making contact with the live parts in case of damage to the instruments or pipelines.

2.4.2 Insulation clearances.

Clearances between live parts at different potentials, or between live parts and earthed metal parts or outer enclosure, both in air and across the insulant surface shall be in conformity with the operating voltage and operating conditions of the installation, with the properties of the insulating materials used duly taken into account.

2.4.3 Internal wiring.

2.4.3.1 Stranded wires shall be used for internal wiring of electrical equipment throughout.
Hookup wires shall be marked according to connection diagram.

2.4.3.2 For internal wiring of switchboards, control desks, other distribution and switching arrangements, etc., wires of not less than 1 mm^2 in cross-sectional area shall be used.

For systems of control, protection, measurement of different parameters, signalling and internal communication the use of wires having a cross-sectional area not less than 0,5 mm^2 is permitted.

For electronic and electrical devices for transformation and transmission of low-power signals wires not less than 0,2 mm^2 in cross-sectional area may be used.

2.4.3.3 Current-carrying parts shall be so attached that they will not have to sustain any additional mechanical stresses; such parts shall not be attached by screws fitted directly into insulating materials.

2.4.3.4 Stranded cores, cables and wires shall have their ends fitted out to suit the type of terminal used, or shall be provided with lugs.

2.4.3.5 Insulated wires shall be laid up and secured in such a manner that the method used for their attachment and arrangement does not lead to reduced insulation resistance and that they are not exposed to damage due to electrodynamic loads, vibrations or shocks.

2.4.3.6 Arrangements shall be made to ensure that the temperatures allowed for insulated wires under normal service conditions or for the duration of short-circuit current breaking are not exceeded.

2.4.3.7 Insulated wires shall be so connected to terminals or busbars that the wire insulation shall not be exposed to the overheating temperature under rated operating conditions.

2.4.4 Protection of electrical equipment.

2.4.4.1 Depending on location, the use shall be made of electrical equipment in appropriate protective enclosure, or other suitable measures shall be taken to protect the equipment from harmful effect of the environment and to protect the personnel from electric shock hazards.

2.4.4.2 The minimal degree of protection of electrical equipment installed in ship's spaces and zones shall be chosen from Table 2.4.4.2.

Table 2.4.4.2

Spaces, in which electrical equipment is installed	**Type of electrical equipment**				
	Electric machines, transformers	**Switchboards, control gear, starters**	**Communication and signalling equipment, automation equipment, accessories (switchers, sockets, junction boxes)**	**Space heating and cooking appliances**	**Lighting fixtures**
1	**2**	**3**	**4**	**5**	**6**
Spaces and zones, in which explosive mixtures of vapours, gases or dust with air are likely to occur	*Ex* (refer to **2.9**, **19.2.4**)	–	*Ex* (refer to **2.9**, **19.2.4**)	–	*Ex* (refer to **2.9**, **19.2.4**)
Dry spaces, dry accommodation spaces	IP20	IP20	IP20	IP20	IP20
Navigation bridge, radio room	IP22	IP22	IP22	IP22	IP22
Service spaces, steering gear rooms, refrigerating plant rooms (except for ammonia equipment), emergency diesel generator rooms, general purpose stores. Pantries, provision stores	IP22	IP22	IP22	IP22	IP22

Engine and boiler rooms	Above plating	IP22	IP22	IP44	IP22	IP22
	Below plating	IP44	–	IP44	IP44	IP44
	Control stations (dry)	IP22	IP22	IP22	IP22	IP22
	Enclosed separator rooms	IP44	IP44	IP44	IP44	IP44
Refrigerated spaces, galleys, laundries, bathrooms and showers		IP44	IP44	IP55	IP44	IP44
Catch processing spaces[1] , shafting tunnels, cargo holds		IP55	IP55	IP55	IP55	IP55
Open decks		IP56	IP56	IP56	IP56	IP56
Premises and spaces protected by the fixed local application fire extinguishing systems [2]		IP44	IP44	IP44	IP44	IP44

[1] For the electrical equipment installed in the catch processing spaces an additional protection is recommended to enable sanitarization of the equipment with sea water.

[2] The electrical equipment within adjacent areas not exposed to direct spray системи (refer to **3.12**, Part VI «Fire Protection»), upon agreement with the Register may have a lower degree of protection provided relevant measures of the electrical equipment protection are taken (e.g. installation of extra inlet ventilation openings, filters, baffles, etc).

Note. Where the enclosure of equipment does not guarantee the necessary protection, alternative methods of protection or alternative arrangement of equipment shall be applied to ensure the degree of protection stipulated by the Table.

2.5 PROTECTIVE EARTHING OF METAL PARTS, WHICH DO NOT CARRY CURRENT

Metal enclosures of electrical equipment operated at a voltage exceeding the safety level or having no double or reinforced insulation shall be fitted with an earth terminal marked with the symbol ⏚.

Provision shall be made for earthing inside and outside of the electrical equipment enclosure dependent on its purpose.

2.5.1 Parts to be earthed.

2.5.1.1 Metal parts of electrical equipment, which are likely to be touched under service conditions and which may become live in the event of damage to the insulation (except for those mentioned under **2.5.1.2**), shall have a reliable electric contact with a component fitted with an earth terminal (refer also to **2.5.3**).

2.5.1.2 Protection earthing is not required for:

.1 electrical equipment supplied with current at safety voltage;

.2 electrical equipment provided with double or reinforced insulation;

.3 metal parts of electrical equipment fastened in non-conducting material or passing therethrough and separated from the earthed and live parts in such a manner that under normal operating conditions these parts cannot become live or come in contact with earthed parts;

.4 bearing housings isolated to guard against circulating currents;

.5 lamp caps and fasteners for luminescent lamps, lamp shades, reflectors and guards supported on lamp holders or lighting fixtures constructed of, or shrouded in non-conducting material;

.6 cable clips, cleats, etc.;

.7 individual consumer - under voltage up to 250 V supplied through an isolation transformer.

.8 equipment that is powered by direct current, the voltage of which is more than 50V, or alternating current, the rms voltage of which between the conductors is not more than 50V, and autotransformers shall not be used to achieve such a voltage.

2.5.1.3 The shields and metal armour of cables shall be earthed.

2.5.1.4 The secondary windings of all instrument transformers for current and voltage shall be earthed.

2.5.2 Earthing of aluminium structures in steel ships.

Superstructures of aluminium alloys fastened to the ship steel hull but insulated therefrom shall be earthed by at least two special wires, which will not start electrolytic corrosion at the points of their contact with the superstructure and the hull.

The conductivity of each wire shall not be lower than the equivalent conductivity of a copper wire having a cross-sectional area of 16 mm^2.

Such earthing connections shall be provided at different locations around superstructure perimeter, shall be accessible for inspection and protected from damage.

2.5.3 Earth terminals and conductors.

2.5.3.1 Bolts for fastening the earthing conductor to the ship's hull shall have a diameter not less than 6 mm. For cables and wires having a cross-sectional area of 2,5 mm^2 and 4 mm^2 it is permitted to use bolts (screws) 4 mm and 5 mm in diameter, respectively.

Such bolts shall not be used for other purposes.

The bolts screwed into material (without nuts) shall be manufactured of brass or other corrosionresistant material.

Ship's hull in places of earthing conductor connections shall be cleaned to metal and properly protected against corrosion.

2.5.3.2 Fixed electrical equipment shall be earthed by means of external earthing conductors or an earthing core in the feeding cable.

When earthing is effected with a special core of the feeding cable, it shall be connected to the earthing device inside the enclosure of the electrical equipment.

Such earthing effected with external earthing conductors need not be provided in case the arrangement of equipment ensures a reliable electrical contact between the equipment enclosure and the metal ship's hull under all operating conditions.

For earthing effected with an external earthing conductors, the use shall be made of copper conductors, as well as conductors of any other corrosion-resistant metal provided the resistance of these conductors does not exceed that of the required copper conductor. The cross-sectional area of copper earthing conductor shall not be less than that specified in Table **2.5.3.2**.

In case earthing is effected with a special core, the cross-sectional area of this core shall be equal to the nominal area of the feeding cable core for cables, having a cross-sectional area up to 16 mm^2 and at least half the cross-sectional area of the feeding cable core, but not less than 16 mm^2 for cables having a crosssectional area over 16 mm^2. Earthing resistance shall not exceed 0,4 Ohm.

2.5.3.3 Earthing of movable, loose and portable consumers shall be effected through and earthed jack in the socket outlet or other earthed contact device and a copper earthing core of the feeding flexible cable.

The cross-sectional area of the earthing core shall not be less than the nominal crosssectional area of the feeding flexible cable core for cables up to 16 mm^2 and at least half the crosssectional area of the feeding flexible cable core, but not less than 16 mm^2, for cables over 16 mm^2.

***Table* 2.5.3.2**

Cross-sectional area of cable core connected to consumer, mm^2	Cross-sectional area of earthing conductor of fixed electrical equipment, mm^2, min	
	solid	stranded
Up to 2,5	2,5	1,5
2,5–120	Half the cross-sectional area of cable core connected, but not less than 4	
Over 120	70	

2.5.3.4 Earthing of the fixed equipment shall be non-disconnectable.

2.5.3.5 Earthing of shields and metal armour of cables shall be effected in one of the following ways:

.1 using a copper earth wire of a cross-section not less than 1,5 mm^2 for cable conductors with a cross-sectional area up to 25 mm^2 and not less than 4 mm^2 for cable conductors with a crosssectional area over 25 mm^2;

.2 by adequate attachment of the shields and metal armour to the hull;

.3 by means of cable gland rings provided these are characterized by corrosion resistance, good conductivity and elasticity.

Except for cables of end branches of circuit, which may be earthed at the supply end only, earthing can be effected at both cable ends.

Cable shields and metal armour may be earthed in another approved way, provided these methods do not hamper the operation of equipment.

2.5.3.6 The external earthing conductors shall be accessible for inspection and protected against getting loose and mechanical damage.

2.6 LIGHTNING PROTECTION

2.6.1 General.

2.6.1.1 In ships provision shall be made for lightning protection devices covering the zone to be protected.

2.6.1.2 In ships, where consequential effects of lightning strokes may cause a fire or explosion, lightning protection earthing devices shall also be fitted to preclude consequential sparking.

2.6.1.3 Lightning protection device shall consist of an air termination, down conductor and earth termination.

On metal masts no special lightning protection device need be fitted if provision is made for reliable electrical connection of the mast to the metal hull or earthing point.

2.6.2 Air termination network.

2.6.2.1 In metal ships the ship's vertical structures (masts, derrick posts, superstructures, etc.) may be used as air termination if provision is made for reliable electrical connection of these structures to the metal hull.

Additional air terminations shall be used only when ship's structural elements proper do not provide for reliable lightning protection.

2.6.2.2 If electrical equipment is installed on the top of the metal mast, provision shall be made for an air termination network, which is effectively earthed.

2.6.2.3 On each mast or top mast of non-conducting material an effectively earthed air termination shall be provided.

2.6.2.4 The air termination shall be made of a rod at least 12 mm in diameter. The rod may be of copper, copper alloys or steel protected against corrosion. For aluminium masts aluminium rods shall be used.

2.6.2.5 The air termination shall be fitted to the mast in such a manner that it projects at least 300 mm above the top of the mast or above any device fitted on its top.

2.6.3 Down conductor.

2.6.3.1 The down conductor shall be made of a rod, strip or multiwire cable having a crosssectional area not less than 70 mm2 for copper or its alloys and not less than 100 mm^2 for steel.

Steel down conductors shall be protected against corrosion.

2.6.3.2 Down conductors shall run on the outer side of masts and superstructures with a minimum number of bends, which shall be gradual and have as large radius as possible.

2.6.3.3 Down conductors shall not run through dangerous spaces and zones.

2.6.3.4 In ships with non-metal hull the down conductor of the lightning protection device shall be laid separately throughout its length (including its connection to the earth termination network), without connecting to the busbars of the protective and operation earthing circuits.

2.6.4 Earth termination network.

2.6.4.1 In composite ships the metal stem or other metal structures immersed in water under any navigation condition may be used as earth termination.

2.6.4.2 Means shall be provided on board the ship to allow for connecting the ship's steel hull or the earth termination network to the shore-based lightning protection device earthing when the ship is in a dock or on a slipway.

2.6.4.3 Earthing of ships with non-conducting hulls shall be in accordance with **1.2** (refer to the definitions **1.2.22**, Part II «Hull»).

2.6.5 Connections in lightning protection device.

2.6.5.1 Connections between the air termination network, down conductor and earth termination network shall be welded or bolted with clamps.

2.6.5.2 The contacting surface area between the down conductor, air termination network and earth termination network shall not be less than 1000 mm^2.

The connecting clamps and connecting bolts shall be made of copper, copper alloys or steel protected against corrosion.

2.6.6 Lightning protection earthing devices.

2.6.6.1 Lightning protection earthing referred to in **2.6.1.2** shall be provided for isolated metal structures, flexible connections, pipes, screens of power and communication lines, pipeline entries into dangerous spaces.

2.6.6.2 All pipelines conveying petroleum products and other pipelines associated with dangerous spaces and zones and located on open decks or in spaces free from electromagnetic screening shall be earthed to the ship's hull at least at 10 m intervals throughout their length.

All pipelines, which are located on the upper deck where explosive gases may be present and which are not associated with dangerous spaces and zones, shall be earthed to the ship's hull at least at 30 m intervals throughout their length.

2.6.6.3 Metal parts near down conductors shall be earthed if they are not fixed to earthed structures and have no other metal connection to the ship's hull.

In so doing, facilities or metal parts located at a distance of up to 200 mm from the down conductor shall be so connected to the down conductor that consequential sparking is excluded.

2.6.6.4 The joints of earthing elements shall be accessible for inspection and protected from mechanical damage.

2.7 ARRANGEMENT OF ELECTRICAL EQUIPMENT

2.7.1 Electrical equipment shall be installed in such a manner as to provide convenient access to controls and to all parts that require maintenance, inspection and replacement.

2.7.2 The horizontal-shaft electric machines shall be so installed that the shaft is positioned parallel to the centre line of the ship. Installation of machines with the shaft positioned in another direction is permitted only in those cases when the design of the machine ensures its normal operation under conditions specified in **2.1.2.2**.

2.7.3 The air-cooled electrical equipment shall be so located that cooling air is not taken from bilges or other spaces wherein the air may be contaminated with substances having a harmful effect on insulation.

2.7.4 The electrical equipment placed in locations subject to vibration and shocks, which are heavier than those specified in **2.1.2.1** and which are impossible to eliminate, shall be so designed as to ensure its normal operation under these conditions or to mounted on relevant shock absorbers.

2.7.5 Electrical equipment shall be fixed in position in such a manner that the strength of decks, bulkheads and skin is not impaired as a result of this.

2.7.6 No electrical equipment shall be located in spaces wherein explosives are stored. Lighting of such spaces shall be provided with lighting fixtures fitted in adjacent flameproof spaces. If this is impracticable, the electrical equipment shall be of the design and type which prevent potential ignition and explosion.

2.7.7 When the enclosures of electrical equipment are made from different material than the structures on which they are installed, care shall be taken, if necessary, to prevent electrolytic corrosion.

2.7.8 When the equipment is located in the areas protected by a local fixed fire extinguishing system, the requirements of **7.13.3** and **7.13.4** shall be obsefved.

2.8 SPECIAL ELECTRICAL SPACES

2.8.1 The doors of special electrical spaces shall be locked. These doors shall open on the outside.

In case the doors face corridors and passageways in accommodation and service spaces, it is permitted that these doors open on the inside on condition that protection guards and stops are provided.

A warning notice shall be placed on the door. From the inside of the space the door shall open without a key.

2.8.2 Special electrical spaces shall not be adjacent to the tanks filled with flammable liquids. If this requirement is not feasible from the structural point of view, measures shall be taken eliminating the possibility of flammable liquid penetration into these spaces.

2.8.3 No exits, side scuttles of the opening type or other openings are permissible from special electrical spaces into dangerous spaces.

2.8.4 Handrails of non-conducting material shall be installed in special electrical spaces, in passageways and servicing areas when the open-type electrical equipment is used.

2.9 SAFE-TYPE ELECTRICAL EQUIPMENT

2.9.1 The requirements of the paragraph are applicable to all ships, in which enclosed or semienclosed spaces and zones explosive mixtures of vapours, gases or dust with air are likely to occur in dangerous concentrations.

The following spaces and zones fall under this category: paint lockers, lantern rooms (for oil lanterns), storerooms for cylinders with flammable gases, battery compartments and spaces, which contain tanks, machinery and pipes for flammable liquids having a flash point 60°C and below.

Additional requirements for installation of electrical equipment in oil tankers are specified in **19.2**;

in ships intended for the carriage of motor vehicles with fuel in their taks - in 19.3;
in ships intended for the carriage of dangerous goods - in **19.11**.

2.9.2 Safe type of the equipment shall be confirmed by a certificate issued by a competent body.

For simple electrical apparatus and components specified in 19.2.4.1.2 and 19.2.4.2.3, a certificate issued by a competent body as regards safety is not required. The manufacturer's confirmation of the product compliance with IEC 60079-11 and 60079-0 (or equivalent national standards) will be sufficient.

2.9.3 In dangerous spaces and zones, only safe type electrical equipment may be installed, the protection level of which corresponds to the category and group of the most dangerous gas mixture.

Electrical equipment installed in the following spaces shall have an explosion protection level and temperature class:

.1 paint lockers - sub-group IIB, temperature class T3 (refer also to **2.9.16**);

.2 storerooms for cylinders with flammable gases - sub-group IIC, temperature class T2;

.3 battery compartments - sub-group IIC, temperature class T1 (refer also to **13.6**);

.4 spaces which enclose tanks, machinery and piping for inflammable liquids having a flash point 60°C and below - sub-group IIB, temperature class T3.

Depth-sounder oscillators and associated cables shall be installed in compliance with the requirements of **3.7.4** and **3.8.3**, Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships, and ventilator motors shall be installed in spaces adapted for the carriage of dangerous cargoes in compliance with **12.7.4**, Part VIII "Systems and Piping".

2.9.4 In spaces where explosive mixture of dust or fibre with air may accumulate electrical equipment with the degree of protection not below IP65 shall be installed.

Electrical equipment of IP55 type may be permitted where the occurrence of explosive mixture of dust or fibre with air is temporary, resulting from the damage or infiltration from processing equipment in operation or ventilation cutoff.

Electrical equipment installed in these spaces shall have such protective enclosure that the temperature of its upper horizontal surfaces or those inclined more than 608 to the horizontal is, under conditions of continuous operation, by 75°C below the smouldering point of dust accumulated in these spaces (the smouldering point shall be determined for a layer of dust 5 mm thick).

2.9.5 Lighting fixtures of safe type shall be so installed that a free space around them is not less than 100 mm, excluding the place of the fastenings.

2.9.6 Any equipment installed in dangerous spaces and zones, except for fire detectors, shall be provided with switches fitted at a safe position outside dangerous spaces and zones to disconnect all live conductors.

2.9.7 Fastening of electrical equipment directly to the walls of tanks intended for flammable liquids is not allowed. In any case, electrical equipment shall be fastened at a distance not less than 75 mm from the tank walls.

2.9.8 In enclosed and semi-enclosed spaces where an explosive mixture of gas or vapour with air is not likely to occur, but direct openings lead to dangerous spaces, electrical equipment of safe type shall be generally installed.

Installation of electrical equipment of non-safe type, is permitted if the following conditions are observed:

.1 operation of alarms (visual and audible) and automatic disconnection of power supply (in sound cases with time delay) to electrical equipment if the ventilation is shut off;

.2 interlocking to provide for possible connection of electrical equipment only after adequate ventilation of the space (at least 10 air changes).

2.9.9 In compartments/holds intended for carriage of flammable cargoes the electrical equipment, which is essential for the safety and control of the ship, shall have a possibility to be completely isolated and protected against unauthorised actuation.

The equipment shall be isolated from locations outside the dangerous zones by removing special disconnectors, by switches with interlocking devices or other effective means.

If provision of such equipment is necessary for the safety and control of the ship, the equipment shall be of certified safe type: intrinsically safe (*Exia* or *Exib*) pressurised enclosure (*Exp*), flameproof (*Exd*), increased safety (*Exe*).

2.9.10 0 In explosion-dangerous spaces and zones only the cables serving the electrical equipment fitted in such spaces and zones in full compliance with the requirements of **2.9.11** may be laid.

The through runs of cables may be permitted in the above spaces and zones provided the requirements of **2.9.11 - 2.9.15** are complied with.

No connections of cables laid in dangerous zones are permitted.

2.9.11 Cables installed in dangerous spaces and zones shall have protective covering of one of the following types:

.1 metal armour or braid with additional insulation covering;

.2 lead sheath with additional mechanical protection;

.3 copper or stainless steel sheath (only for cables with mineral insulation).

2.9.12 Cables passing through dangerous spaces and zones shall be suitably protected against mechanical damage.

Penetrations of cables through decks and bulkheads shall be sealed to avoid ingress of flammable gases or vapours.

2.9.13 All shields and metal braids of cables of power circuits for electric motors and lighting systems, which pass through dangerous spaces and zones or supply the electrical equipment installed in these spaces, shall be earthed at both ends at least.

2.9.14 Cables of intrinsically safe circuits shall be laid separately from other cables.

2.9.15 Cables of portable electrical equipment, except for cables of intrinsically safe circuits, shall not pass through dangerous spaces and zones.

2.9.16 Additional requirements for electrical equipment installed in paint lockers.

2.9.16.1 Electrical equipment shall be installed in paint lockers and in ventilation ducts serving such spaces only when it is essential for operational services.

Safe type equipment of the following type is acceptable: intrinsically safe (*Exi*), pressurized (*Exp*), flameproof (*Exd*), increased safety (*Exe*), special protection (*Exs*).

2.9.16.2 The minimum requirements for the safe type equipment are as follows: explosion group IIB, temperature class T3.

2.9.16.3 In paint lockers and spaces mentioned under **2.9.16.4**, cables (through-runs or terminating cables) of armoured type or installed in metallic conduits shall be used.

2.9.16.4 In the areas on open deck within 1 m of inlet and exhaust ventilation openings or within 3 m of exhaust mechanical ventilation outlets, the following electrical equipment may be installed: safe type equipment permitted by **2.9.16.1**, equipment of protection class (Exn), appliances, which do not generate arcs or sparks in service and which surface does not reach unacceptably high temperature under normal conditions.

2.9.16.5 Enclosed spaces giving access to the paint locker may be considered as non-hazardous, provided that:

.1 the door to the paint locker is a gastight door with self-closing devices without holding-back arrangements;

.2 the paint locker is provided with an acceptable, independent, natural ventilation system ventilated from a safe area;

.3 warning notices are fitted adjacent to the paint locker entrance stating that the store contains flammable liquids.

2.10 ANTISTATIC EARTHING

2.10.1 Antistatic earthing is a mandatory mean of ensuring electrostatic intrinsic safety for all types of ships having dangerous spaces and zones.

2.10.2 Equipment to be installed on board, in enclosed and semi-enclosed spaces and zones where explosive mixtures of vapours, gases or dust with air likely to occur (refer to **2.9.1**), as well as any portable equipment to be brought and installed in such spaces shall be antistatically earthed.

2.10.3 Bonding straps shall be required for cargo tanks/process plant/piping systems which are not permanently connected to the hull of the ship, e.g.:

.1 independent cargo tanks;

.2 cargo tanks/piping systems which are electrically separated from the hull of the ship;

.3 pipe connections arranged for the removal of spool pieces;

.4 wafer-style valves with non-conductive (e.g PTFE) gaskets or seals;

2.10.4 The following equipment does not require use of the antistatic earthing conductors:

.1 fixed and portable electrical equipment shields and metal armour of cables earthed in accordance with **2.5**;

.2 pipes and conduits for installation of cables earthed in accordance with **16.8.8**;

.3 electrical equipment, automation equipment, radio equipment and navigational equipment earthed in accordance with **2.2.2**;

.4 equipment and structures provided with lightning protection earthing in accordance with **2.6.6**.

2.10.5 Arrangement and monitoring of antistatic earthing.

2.10.5.1. Bonding straps shall be designed and sited so that they are protected against mechanical damage and that they are not affected by high resistivity contamination e.g. corrosive products or paint.

Bonding straps shall be clearly visible so that any shortcomings can be clearly detected.

Bonding straps shall be easy to install and replace.

Bonding straps shall be connected to the non-metallic equipment, e.g. plastic pipes, in a manner defined by the manufacturer of the equipment.

2.10.5.2 Design of the bonding straps being the component part of the equipment delivered to the ship shall meet the requirements of relevant Parts of the Rules or the standards approved by the Register.

2.10.5.3 Resistance of the antistatic earthing shall be monitored by portable instruments of any type with control d.c. voltage of not more than 10 V.

The resistance value measured between the equipment, component, structure being monitored and ship's hull shall not exceed 10^6 Ohm with the area of contact between the measure electrode and the equipment surface being no more than 20 mm^2.

2.11 ARRANGEMENTS AND SYSTEMS FOR INSULATION RESISTANCE MONITORING

2.11.1 In each isolated ship power system with the nominal voltage above 50 VAC or above 110 V DC provision shall be made for an automatic continuous monitoring of insulation resistance of currentcarrying components relative to ship's hull.

Measurements periodicity during the periodic monitoring shall not exceed 300 s.

2.11.2 In the networks with the voltage 1000 V and above monitoring of the insulation resistance shall be carried out only alive with the use of passive monitoring methods (for example, with the use of zerosequence current transformer).

2.11.3 Devices for insulation resistance monitoring in the networks with the voltage up to 1000 V shall:

be fitted with an indicator showing the insulation resistance value; have visible and audible alarm at decrease of controlled value under the prescribed limit;

allow to perform smooth adjustment of alarm actuating setting value within the range from 100 to 5 kOhm. The current setting value shall be indicated;

have an operation speed sufficient for measuring insulation resistance value in the networks with the existing capacity level during the measurement cycle of the device which shall not exceed 30 s;

produce measuring current not exceeding 0,03A under all modes (including transient);

provide for the possibility of periodic intactness monitoring under operational conditions by means of earth leakage current through an active resistance equal to 80 % of resistance of the relevant setting actuating.

2.11.4 Location of devices for insulation resistance monitoring shall meet the requirements of **4.6.4.7**.

3. MAIN ELECTRICAL POWER SOURCE

3.1 COMPOSITION AND CAPACITY OF MAIN ELECTRICAL POWER SOURCE

3.1.1 In every ship, a main electric power source shall be provided with a capacity sufficient to supply all the electrical equipment on board under conditions specified in **3.1.5**.

Such a source shall consist of two independently driven generators at least. In ships of 300 gross tonnage and below (except for passenger ships), accumulator batteries may be the main power source.

3.1.2 The number and capacity of independently driven generators and electric converters, of which the main electrical power source is composed, shall be such that if any of them failed the rest would ensure:

.1 supply to electrical equipment essential for propulsion, steering and safety of the ship with the normal habitable conditions on board guaranteed;

.2 start of the most powerful electric motor with the greatest starting current. The motor start shall not involve a voltage and frequency drop in the mains that could result in a fall out of synchronism, stop of generator engine or disconnection of machinery and apparatus being in operation;

.3 supply to consumers necessary to start the propulsion plant (refer to **1.2.1**, Part VII "Machinery

Installation") when the ship is de-energized. For this purpose, emergency electrical power source may be used if its capacity proper or in association with the capacity of any other electrical power source would ensure a simultaneous supply of consumers listed under **9.3.1** to **9.3.3** or under **19.1.2.1** to **19.1.2.3** (refer also to **2.1.6**, Part VII "Machinery Installations"), for this purpose their parallel operation may be provided.

3.1.3 Where the main electrical power source is needed to ensure propulsion and steering of the ship, provision shall be made that the power supply to the equipment essential for propulsion and steering and to ensure safety of the ship is maintained continuously or restored immediately in case of failure of any generator being in operation.

Along with that, in ships where electrical power is normally supplied by two or more generators running in parallel, provision shall be made for automatic switching-off of less essential consumers without any overloading of the remaining generators, with retention of power supply to consumers essential for propulsion, steering and to ensure safety of the ship.

In ships where electrical power is normally supplied by one generator, in case of its failure and deenergization of the main switchboard, provision shall be made for:

automatic starting of stand-by generator of sufficient capacity and its connection to busbars of the main switchboard within 45 s;

automatic re-starting, in the necessary sequence, of essential devices ensuring propulsion, steering and safety of the ship.

3.1.4 Instead of one independently driven generator as mentioned under **3.1.1**, a generator driven by the main engine (shaft generator) may be used if it complies with **3.2.3** under conditions listed below:

.1 the shaft generator operates practically at a constant speed (in the set frequency range for an electrical power plant with variable frequency main power source) under different operating conditions of the ship;

.2 provision is made for actuation of the ship's propulsion plant in case of failure of any generator with an independent prime mover.

3.1.5 The number and power output of generators forming the main source of electrical power shall be determined with regard to the following operating conditions of the ship:

.1 running conditions;

.2 manoeuvring;

.3 in case of fire, hole in the ship's hull or other conditions affecting the safety of navigation, with the main sources of electrical power in operation;

.4 other operating conditions according to ship's purpose.

3.1.6 Where accumulator batteries are the main source of electrical power, their capacity shall be sufficient to satisfy the requirements of **3.1.2.1** for 8 h without recharging; provision shall be made for charging of accumulator batteries from the source of electrical power installed on board.

3.1.7 In ships of restricted area of navigation **R3** and **R3-IN** (except passenger ships) with a low-power electrical installation as the main source of electrical power, only one generator with an independent prime mover or accumulator batteries may be installed.

3.2 GENERATOR SETS

3.2.1 General.

3.2.1.1 Engines designed for use as generator prime movers shall comply with the requirements set forth in Sections **2**, **3** and **8**, Part IX "Machinery", and, additionally, with the requirements of the Chapter.

3.2.1.2 Electric machine sets shall be designed for continuous duty, with regard to the power reduction during ship's service under conditions specified in **2.1.1.1**.

3.2.1.3 Under short circuit in the ship's mains the generators shall provide for the value of the sustained short-circuit current sufficient for the operation of protective devices.

3.2.1.4 The voltage of generators shall be regulable within the range specified in **10.6** and **10.7** of this Part, and speed frequency shall be regulable within the range specified in **2.11.3**, Part IX "Machinery".

3.2.2 Load sharing between sets running in parallel.

3.2.2.1 Alternating-current sets intended to run in parallel shall be provided with such a reactivevoltage drop compensating system that when the sets run in parallel the reactive load sharing between the generators does not differ from a value proportional to their output by more than 10 % of the rated reactive load of the largest generator involved or by not more than 25 % of the rated output of the smallest generator if this value is lower than the above one.

3.2.2.2 When the alternating-current sets run in parallel at 20 to 100 % of the total load, load sharing shall be within the limits specified in **2.11.3**, Part IX "Machinery"..

3.2.3 Shaft generator sets.

3.2.3.1 Where shaft generators are used for feeding the ship mains, automatic connection of one or more independently driven generators to the ship mains shall be provided, or an alarm shall be activated in the engine room or at the main machinery control room in case the network frequency is below the permissible value.

3.2.3.2 Shaft generators intended for supply of particular consumers may operate under parameters, which differ from those specified in **3.2.1.4**.

3.2.3.3 Shaft generators and semiconductor transducers (inverters) supplying the ship mains shall not be damaged by short circuits at the main distribution board busbars. In this case, a steady shortcircuit current shall be ensured, sufficient for protection to be activated.

3.2.3.4 As a minimal requirement, shaft generators shall be designed for short periods of parallel running with other types of generator sets so that manual or automatic (if available) switch-over of the load is possible.

3.2.3.5 For shaft alternators, automatic devices shall be provided to preclude the current overload of their excitation system components when running at a speed below 90 % of the nominal speed during more than 5 s. In this case, a proportional voltage lowering across the generator terminals is permitted.

3.2.3.6 For each shaft generator, a de-excitation device shall be provided at the main distribution board, and measuring instruments as listed under **4.6.4.3**.

3.2.3.7 When the shaft generator is connected into the ship mains, a visual warning signal shall be activated at the navigation bridge indicating that a change in the mode of main machinery operation might bring about a deviation in the ship main parameters beyond the limits stipulated by **10.6** and **10.7** of this Part and **2.11.3**, Part IX "Machinery".

3.2.3.8 A generator with an independent prime mover may be used in shaft generators with semiconductor converters as a synchronous condenser. In such cases, a disengaging clutch shall be fitted between the generator and its prime mover.

3.2.4 Exhaust-heat turbogenerators.

3.2.4.1 Exhaust-heat turbogenerators supplying particular consumers may have performance characteristics different from those stated under **3.2.1.4**.

3.2.4.2 The exhaust-heat turbogenerators used for feeding the ship mains shall be designed for parallel operation with generators having an independent prime mover. In this case, the distribution of load between the generator sets shall be in accordance with **3.2.2**.

3.3 NUMBER AND CAPACITY OF TRANSFORMERS

3.3.1 1 In ships, where lighting and other circuits of essential services are powered through transformers, not less than two transformers shall be provided of such a capacity that in case of failure of the largest unit, the remaining transformers are capable of satisfying the complete need in electrical power under all operating conditions of the ship.

Where subdivided system of busbars is used, transformers shall be connected to different sections of the main switchboards. In ships of less than 300 gross tonnage (other than passenger ships) of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS**, **R3**, **R3-IN** with the electrical installation of low power installation of only one transformer is allowed.

3.4 POWER SUPPLY FROM AN EXTERNAL SOURCE OF ELECTRICAL POWER

3.4.1 If provision is made for ship's mains to be supplied from an external source of electrical power, an external supply switchboard shall be installed in the ship (refer also to **4.6.4.6**).

For ships with the electrical installation of low power it is allowed that cables for supply of the ship's mains from an external source of electrical power shall be connected to the main switchboard directly.

3.4.2 At the external supply switchboard, the following facilities shall be provided:

.1 terminals for flexible cable connection;

.2 switch gear and protection devices for connecting and protection of permanently laid cable of the main distribution switchboard; where the cable length between the external supply switchboard and the main distribution switchboard is less than 10 m, no protection devices may be fitted;

.3 voltmeter or pilot lamps to indicate the presence of voltage from an external source across the terminals;

.4 device or facilities for connecting a device to control polarity and phase sequence;

.5 terminal for earthing a neutral wire from an external source;

.6 plate to indicate voltage, type of current and frequency;

.7 arrangement for mechanical fixation of the end of flexible cable connected to the switchboard and a hanger for the cable, which shall both be provided at the external supply switchboard or in its vicinity.

3.5 CONNECTION OF ELECTRICAL POWER SUPPLY UNITS

3.5.1 Where the electrical power supply units are not adapted for long operation in parallel to feed common busbars, it is necessary to use a connection circuit ensuring their switching-on for parallel operation for the duration of load transfer from one unit to another.

3.5.2 Direct current compound-wound generators designed for parallel operation shall have equalizing connections.

3.5.3 Where alternating-current generators are intended to operate in parallel, a synchronizer shall be installed in the main switchboard. Where synchronizing is arranged to operate automatically, a standby manual synchronizer shall be provided by one operator.

3.5.4 Where several direct-current generators are installed, a magnetizing device shall be fitted in the main switchboard. Such device may be also allowed for synchronous alternating-current generators if it is necessary for initial excitation.

3.5.5 Where the ship's and external sources of electrical power are not intended to operate in parallel to the common busbars of the ship's electrical installation, the system of connections shall be so interlocked, in this case, as to prevent their possible switching-on for parallel operation.

3.5.6 Where the main source of electrical power is necessary for propulsion of the ship, the main busbar shall be subdivided into at least two parts, which shall normally be connected by circuit breakers or other approved means (e.g. circuit breaker without release or disconnector).

Bolted links between the main switchboard sections, by which the busbars can be split, are not acceptable.

So far as it is practicable, the connection of generating sets and other duplicated equipment shall be equally divided between the parts.

4. DISTRIBUTION OF ELECTRICAL POWER

4.1 DISTRIBUTION SYSTEMS

4.1.1 The following systems of electrical power distribution are acceptable:

.1 for alternating current up to and including 1000 V:

.1.1 three-phase three-wire insulated system;

.1.2 three-phase three-wire system with neutral earthed through high-value resistor or reactor (compensated-resistored neutral);

.2 additionally for current up to and including 500 V:

.2.1 three-phase four-wire insulated system;

.2.2 three-phase four-wire system with neutral earthed according to **4.1.1.1.2**;

.2.3 single-phase two-wire insulated system;

.2.4 single-phase two-wire system with neutral earthed according to **4.1.1.1.2**;

.2.5 single-phase single-wire system with hull return for voltage up to 50 V (in ships of less than 1600 gross tonnage), except stated in **6.8.4**, provided that any possible current will not pass directly through any of the dangerous spaces;

.3 for direct current:

.3.1 two-wire insulated system;

.3.2 single-wire system with hull return for voltage up to 50 V (in ships of less than 1600 gross tonnage), except stated in **6.8.4**, provided that any possible current will not pass directly through any of the dangerous spaces.

Where a hull return system is used, all final circuits shall be two-wire and the insulated return wire shall be earthed by connecting to the earthing busbar of the distribution board supplying the circuit, at the place accessible for inspection. In this case devices shall be provided for isolating the earthing busbars from the hull to test insulation condition.

In ships of 1600 gross tonnage and upwards the use of local earthed systems is accepted for supplying the following consumers (provided that any possible current will not pass directly through any of the dangerous spaces and zones):

.1 electrical (battery) starter systems of internal combustion engines;

.2 impressed-current cathodic protection systems; .3 insulation resistance monitoring and measuring systems (refer to **4.6.4.7**).

4.2 PERMISSIBLE VOLTAGE

4.2.1 Proceeding from the electrical power distribution system used, the permissible voltage across the terminals of power generating sets of electrical power sources with frequencies of 50 and 60 Hz shall be found under **4.1**.

Additonal requirements for apparatus designed for a voltage in excess of 1000 V shall be found in Section **18**.

4.2.2 Permissible voltage across the terminals of sources of electrical power and direct current sources shall not exceed the values below:

500 V for power systems;

250 V for lighting and heating systems, and socket outlets.

4.2.3 Permissible voltage across the terminals of alternating-current consumers shall not exceed the values specified in Table **4.2.3**.

Table 4.2.3

№	Consumers	Permissible voltage, V
1	**2**	**3**
1	Permanently installed power consumers, cooking and heating appliances permanently installed in spaces other than those specified in item **2**	1000
2	Portable power consumers supplied from socket outlets fixed in position when used, heaters in cabins and passenger accommodation (refer to **15.2.5**)	500
3	Lighting, signalling and internal communication, socket outlets for portable consumers with double or reinforced insulation or isolated electrically by isolating transformer	250
4	Socket outlets fitted in locations and spaces with increased humidity, and in extra humid spaces, and intended for supply of consumers having no double or reinforced insulation and not isolated electrically	50

4.2.4 Permissible voltage across the terminals of direct-current consumers shall not exceed the values specified in Table 4.2.4.

Table 4.2.4

№	**Consumers**	**Permissible voltage, V**
1	Permanently installed power consumers	500
2	Cooking, heating, etc. appliances	250
3	Lighting, socket outlets [1]	250

[1] In spaces with increased humidity and extra humid spaces, notices shall be provided at socket outlets with voltage exceeding the overrating voltage to notify of the use of consumers with double or reinforced insulation or those electrically isolated from overrating voltage

4.3 POWER SUPPLY OF ESSENTIAL SERVICES

4.3.1 The following services shall be supplied by separate feeders from the main switchboard busbars:

.1 steering gear electric drives (refer also to **5.5.2**);

.2 anchor gear electric drives (refer also to **4.3.3**);

.3 fire pump electric drives;

.4 bilge pump electric drives;

.5 electric drives of sprinkler system compressors and pumps equipment to ensure operating of foam generators of high expansion foam system;

.6 gyrocompass;

.7 refrigerating plant switchboard for cargo holds;

.8 electric drives of exciter sets of propulsion plant;

.9 section main-lighting switchboards;

.10 radio equipment switchboard;

.11 switchboard of navigational equipment;

.12 navigation light switchboard;

.13 section switchboards and distribution gear for supplying other essential services combined on the principle of uniformity of their functions;

.14 switchboards of integrated bridge control console (refer also to 4.5);

.15 switchboard of automatic fire detection system;

.16 electric drives of auxiliaries ensuring the operation of main machinery;

.17 switchboards of electric drives for cargo, mooring, boat and other gears, ventilation and heating appliances;

.18 control devices of controllable pitch propeller;

.19 charging facilities of starter accumulator batteries and batteries supplying essential consumers;

.20 switchboards of electric drives for closure of watertight doors and devices holding fire doors in open position and closure of watertight and fire doors;

.21 switchboard of refrigerating plant for the low pressure carbon dioxide extinguishing system;

.22 lighting switchboards for hangars and helicopter deck illumination;

It is permitted to supply services indicated in **.4, .10, .11, .12, .15, .16, .18, .19, .20** from switchgear indicated in **.13** or **.14**, by separate out-going feeders provided with adequate switching and protective devices.

4.3.2 In case one-purpose machinery with electric drives indicated in **4.3.1** is installed in double or greater number, except for specified in **4.3.1.1**, **4.3.1.5** and **4.3.1.8** at least one of these drives shall be energized by a separate feeder from the main switchboard. Electric drives of the rest of such machinery are allowed to be supplied from section switchboards or special distribution devices intended for supply of essential services.

When the collecting busbars in the main switchboard are subdivided into sections having intersectional disconnecting devices, the electric drives, section switchboards, special distribution devices or boards installed in double or greater number or supplied by two feeders shall be connected to different sections of the main switchboard.

4.3.3 In cargo ships of restricted areas of navigation **R2**, **R2-S**, **R2-RS**, **R3-S**, **R3-RS**, **R3**, and **R3-IN**, and in particular cases in ships of unrestricted service and ships of restricted area of navigation **R1**, the supply feeder of anchor gear may be connected to the distribution board of cargo winches or to another distribution board, on special approval of the Register, provided the boards are supplied directly from the main distribution board and adequate protection is available.

4.3.4 Final sub-circuits having a current rating in excess of 16 A shall supply not more than one consumer.

4.4 POWER SUPPLY OF ELECTRICAL (ELECTRONIC) AUTOMATION SYSTEMS

4.4.1 Power supply of electrical (electronic) automation systems shall satisfy the requirements of Part XV "Automation".

4.4.2 Power supply of automation devices necessary for starting and operating the emergency diesel generator shall be taken from a starter battery or another independent accumulator battery installed in the emergency diesel generator space.

4.5 POWER SUPPLY TO INTEGRATED BRIDGE CONTROL CONSOLE

4.5.1 When locating in the integrated bridge control console the electrical equipment, navigational equipment, radio equipment, electrical automatic and remote-control equipment for the main and auxiliary machinery, such equipment shall be supplied by separate feeders as required in this Chapter and other parts of the Rules.

It is allowed to feed the equipment specially listed in **4.3.1** from the switchboards of the integrated bridge control console, provided the requirements of **4.5.2** to **4.5.6** are met (refer to **9.4.3** as well).

4.5.2 The switchboards of the integrated bridge control console shall be fed from the main switchboard directly or through the transformers by two independent feeders connected to different sections of the main switchboard busbars, where busbars are subdivided.

When the emergency generator is provided on board the ship, the switchboards of the integrated bridge control console shall be supplied by one feeder from the main switchboard and by one feeder from the emergency switchboard.

4.5.3 In addition, the switchboards of the integrated bridge control console shall be independently supplied by a separate feeder from other source or sources of power, if necessary, basing on the requirements for the equipment fed from these switchboards.

4.5.4 The switchboard shall be provided with a change-over switch for feeders specified in **4.5.2**. If an automatic change-over switch is used, manual switching of feeders shall be also ensured. In this case, provision shall be made for necessary interlocking.

4.5.5 Each consumer specially listed in **4.3.1** fed from the switchboards of the integrated bridge control console shall be supplied by a separate feeder (refer also to **9.4.3**).

4.5.6 In the integrated bridge, control console a light signalling device indicating the presence of voltage shall be fitted.

4.6 SWITCHBOARD AND SWITCHGEAR

4.6.1 Switchboard design and construction.

4.6.1.1 Frames, front panels and enclosures of main, emergency, section and distribution switchboards shall be constructed of metal or some other durable non-combustible material.

Where the aggregate capacity of generators intended for parallel operation exceeds 100 kW, barriers shall be installed between the generator sections and adjacent sections for protection against the effects of arcs.

4.6.1.2 Switchboards shall be of rigid construction capable of withstanding the mechanical stresses liable to occur under service conditions or as a result of short circuits.

4.6.1.3 Switchboards shall at least be protected from drip. This protection is not required if the switchboards shall be located in spaces where the conditions are such that no vertically falling drops of liquid can get into the switchboard (refer also to **4.6.6.2**).

4.6.1.4 Switchboards intended to be installed in places accessible to unauthorized persons shall be provided with doors to be opened by means of a special key, the same for all the switchboards in the ship.

4.6.1.5 The design of switchboard doors shall be such that with the doors opened access is assured to all parts which require maintenance, and the live parts located on the doors shall be protected against inadvertent touching.

Opening panels and doors, which are used for mounting electrical control gear and measuring instruments, shall be securely earthed with at least one flexible connection.

4.6.1.6 Handrails shall be fitted to main, emergency and section switchboards and to control panels on their front sides. Switchboards accessible from the rear shall be provided with horizontal handrails fitted at the back.

The materials, which may be used for manufacture of handrails, are insulating material, wood or earthed metal pipes with insulating covering.

4.6.1.7 The generator panels of main switchboards shall be illuminated with lighting fixtures supplied on the generator side before the circuit breaker of the generator or not less than from two different busbar systems in case these systems are provided according to **3.5.6**.

When no such systems are provided, lighting fixtures may be supplied from the emergency switchboard.

4.6.1.8 The lighting of the front side of switchboard panels shall not interfere with instrument observation or produce a blinding effect.

4.6.1.9 The design of switchboards and control consoles not accessible from the rear shall be such that the access is ensured to all parts requiring maintenance.

Arrangements shall be provided for doors of switchboards to fix them in the open position.

Withdrawable blocks and instruments shall be fitted with devices to prevent their fall-out in the withdrawn position.

4.6.1.10 Each distribution device designed for voltage over the safe, with switchgear and protective devices and without a voltmeter, shall be furnished with a pilot lamp, which indicates the presence of voltage on busbars.

4.6.2 Busbars and uninsulated conductors.

4.6.2.1 The maximum permissible temperature for switchboard busbars and uninsulated conductors at the rated load and short-circuit current or at the permissible one-second short-circuit load for copper busbars shall be determined according to national standards.

4.6.2.2 Equalizer busbars shall be designed for at least 50 % of the rated current of the largest generator connected to the main switchboard.

4.6.2.3 Where the busbar is in contact with or close to insulated parts, its heat effects shall not cause under operating or short-circuit conditions a temperature rise in excess of that allowable for a given insulating material.

4.6.2.4 Busbars and uninsulated conductors in switchboards shall have adequate electrodynamic and thermal strength during short-circuit currents occurring at relevant points in the circuit.

Such electrodynamic loads as occur in busbars and uninsulated conductors due to short circuit shall be as specified in the relevant national standards.

4.6.2.5 Insulators and other parts designed to support busbars and uninsulated conductors shall be capable of sustaining the loads due to short circuits.

4.6.2.6 The natural frequency of copper tier busbars shall be outside the ranges of 40 to 60 Hz and 90 to 110 Hz for rated frequency of 50 Hz, 50 to 70 Hz and 110 to 130 Hz for rated frequency of 60 Hz.

4.6.2.7 Busbars and uninsulated conductors of different polarity shall be marked with the following distinguishing colours:

.1 red for positive pole;

.2 blue for negative pole;

.3 black or green and yellow for earth connections;

.4 light blue - for middle wire.

The equalizer connection shall be marked with white transverse bands in addition to the appropriate colour as given above.

4.6.2.8 Busbars and uninsulated conductors of different phases shall be marked with the following distinguishing colours:

.1 yellow for phase 1;

.2 green for phase 2;

.3 violet for phase 3;

.4 light blue for neutral wire;

.5 green and yellow for earth connections.

4.6.2.9 Busbars shall be connected so as to prevent corrosion in way of connections.

4.6.3 Calculation of short-circuit currents and selection of electrical switch apparatus.

4.6.3.1 Electrical switch apparatus shall be calculated on the basis of, at least, relevant national standards. They shall be selected so as to comply with the following requirements:

under normal service conditions, their rated voltages, rated loads and permissible temperature shall not be exceeded;

during transitional conditions, they shall endure expected overloads so that their damage and heating to dangerous temperatures is excluded;

under short-circuit conditions, their specifications shall match expected short circuit current values on leads (terminals) of each switching apparatus, at the design value of power factor.

4.6.3.2 Rated breaking capacity, (I_{cn}) of electrical switch apparatus, which are intended for short circuit clearing, at the moment of breaking in their connection point shall be at least equal to:

effective value of a sinusoidal component of expected short circuit current (I_{ac}) for alternate current;

expected short circuit current with the stated device time constant, for direct current.

4.6.3.3 Maximum rated making capacit, (I_{cm}) of electrical switch apparatus, which can be connected to a shorted electric circuit, shall be at least equal to expected peak short circuit current (I_p) in their connection point.

4.6.3.4 Peak electrodynamic withstand current of electrical switch apparatus, which are not intended for short circuit clearing, shall be at least equal to expected peak short circuit current (I_p) in their connection point.

4.6.3.5 Thermal short circuit strength of electrical switch apparatus shall match with thermal impact of a sinusoidal component of expected short circuit current (effective value) (I_{ac}) in their connection point, for the time of short circuit determined by selective operation of protection devices.

Note. Thermal strength of an electrical switch apparatus is calculated as a squared effective value of a sinusoidal component of expected short circuit current, kA, multiplied by time, *s*, $I^2 \times t$, and hall be specified in its specifications.

4.6.3.6 Rated allowable short-time current (I_{cw}) for electrical switch apparatus installed in selective protection circuits shall be at least equal to effective value of a sinusoidal component of expected short circuit current in the first half-period ($I_{cw} > I_{ac}$).

4.6.3.7 If an automatic circuit breaker does not possess maximum operation rated breaking capacity (I_{cs}), and maximum rated making capacity (I_{cm}), matching with the expected short circuit current in the connection point, it may be used provided that it is protected from the generator side with fuses and/or an automatic circuit breaker, which has at least sufficient rated values of short-circuit currents and does not serve as an automatic circuit breaker of a generator.

Similar protection devices, which gave only a rated maximum limit breaking capacity, (I_{cu}) shall not be installed in main and emergency switchboards or used in circuits of essential and emergency consumers.

Specifications of these devices shall satisfy the following requirements:

.1 if maximum expected short circuit current is cleared, the automatic circuit breaker on the load side shall not be damaged beyond further operability;

.2 if an automatic circuit breaker makes maximum expected short circuit current, the remaining part of electric installation shall not be damaged; in this case the automatic circuit breaker on load side may be not immediately operable.

4.6.3.8 Electric circuits with rated load current in excess of 320 A shall be fitted with automatic circuit breakers to ensure overload protection.

It is recommended to use automatic circuit breakers if current value exceeds 200 A.

4.6.3.9 If direct current compoundwound generators intended for simultaneous running are used, their circuits breakers shall be fitted with a sensing wire pole, which is mechanically connected to other switch poles, so that it switches on, once other poles are connected to buses, and switches off once they are disconnected.

4.6.3.10 Short-circuit current shall be calculated on the basis of the standards or calculation methods approved by the Register.

4.6.3.11 In calculations of the maximum and minimum short-circuit currents a source of short-circuit current shall contain all generators including synchronous condensers, which may be connected in parallel, and all electric motors running simultaneously and able to produce current contribution to the short-circuit point[1].

Calculation is carried out at three-phase "metal" short-circuit.

Calculation of short-circuit currents shall be performed for all electric circuits where electrical equipment is installed which was selected and monitored with regard to permissible short-circuit current supplied directly from the busbars of the main switchboard, including busbars of switchboards for their testing for electrodynamic withstandability and heating while passing of short-circuit current.

[1] Electrical motors supplied from semiconductor converters do not produce current contribution.

These calculations shall be made at least for the following points: on the generator side on the automatic circuit breaker terminals;

on the main switchboard busbars;

on the emergency switchboard busbars;

on the terminals of electric power consumers and busbars of the switchboards supplied directly from the main switchboard.

For evaluation of protective sensitiveness the calculation shall be made both of maximum and minimum short-circuit currents at the terminals of power consumers.

Calculation of short-circuit current in the circuit from the generator terminals up to the main switchboard busbars is made at the outputs of the generator automatic circuit breaker.

Short-circuit current at the generator terminals is calculated with the availability of inner short-circuit protection of stator winding (for example, differential protection).

The results of short-circuit current calculation shall contain the list of all the electrical switch apparatus fitted and their parameters, as well as the maximum and minimum prospective short-circuit current at the points of their installation.

4.6.3.12 Requirements for short-circuit currents in systems with electrical power distribution for direct current are specified in **22.3.4**.

4.6.4 Electric switch apparatus and instrumentation.

4.6.4.1 Apparatus, measuring and indicating instruments used in connection with generators and other large essential installations shall be fitted on the switchboards associated with the appropriate generators and installations.

This requirement may be dispensed with in the case of generators where there is a central control console with switch gear and measurements for several generators.

4.6.4.2 One ammeter and one voltmeter shall be provided for each direct-current generator on the main and emergency switchboards.

4.6.4.3 The following instruments shall be provided for each alternating current generator on the main switchboard and for emergency generator on the emergency switchboard:

.1 an ammeter with a selector switch for current measurements in each phase;

.2 a voltmeter with a selector switch for measuring phase or line voltages;

.3 a frequency indicator (use of one double frequency indicator is permissible for generators operating in parallel with change-over to each generator);

.4 a wattmeter (for output upwards of 50 kVA);

.5 other instruments as required.

4.6.4.4 In ships having a low-power electrical installation, in which the generators are not expected to operate in parallel, one set of instruments as stipulated by **4.6.4.2** and **4.6.4.3** may be installed at the main and emergency switchboards, which would ensure a possibility of taking measurements at each generator installed.

4.6.4.5 Ammeters shall be installed in the circuits of essential consumers rated at 20 A and over. These ammeters may be installed on the main switchboard or at the control stations. It is allowed to install ammeters with selector switches but not more than for six consumers.

4.6.4.6 In the main switchboard the feeder energized from the external power source shall be provided with:

.1 switchgear and protective devices;

.2 a voltmeter or a pilot lamp;

.3 means of protection against phase breaking.

4.6.4.7 A change-over arrangement or a separate device for each network of isolated systems for measuring and indicating insulation resistance shall be installed on the main and emergency switchboards.

In any case, the hull leakage current due to the ope-ration of the measuring device shall not exceed 30 mA.

Provision shall be made for audible and visual alarms to warn of inadmissible decrease in the insulation resistance.

In ships with unattended machinery spaces this signalling shall be also provided at the ship's main machinery control room.

4.6.4.8 Measuring instruments shall have scales with a margin of divisions in excess of the rated values of quantities to be measured.

The upper scale limits of the instruments used shall not be less than:

.1 for voltmeters - 120 % of the rated voltage;

.2 for ammeters associated with generators not operating in parallel and with current consumers - 130 % of the rated current;

.3 for ammeters associated with parallel-operating generators - 130 % of the rated current for load-current scale and 15 % of the rated current for reverse-current scale (the latter refers only to directcurrent generators);

.4 for wattmeters associated with generators not operating in parallel - 130 % of the rated output;

.5 for wattmeters associated with generators opera-ting in parallel _ 130 % for power scale and 15 % for reverse power scale;

.6 for frequency indicator - ±10% of the rated frequency.

4.6.4.9 Voltage, current and power ratings of electric power plant and generators shall be clearly indicated on the scales of electrical measuring instruments.

4.6.4.10 Wherever possible, switchgear shall be installed and connected to busbars in such a way that none of the movable elements and protective or control devices associated with switchgear are energized in the open position.

4.6.4.11 When switches with fuses are installed in outgoing circuits of switchboards, the fuses shall be positioned between the busbar and the switch.

4.6.4.12 Where switchboards are installed on a foundation at the floor level, the fuses shall be located not lower than 150 mm and not higher than 1800 mm from the floor level.

Live open parts of switchboards shall be located at a height of not less than 150 mm above the floor level.

4.6.4.13 Fuses shall be so installed in switchboards that they are easily accessible and the fuse link replacement is not dangerous for the operating personnel.

4.6.4.14 The fuses protecting the poles or phases of the same circuit shall be installed in a row, horizontally or vertically depending on the fuse design.

The fuses in an a.c. circuit shall be positioned to follow the sequence of phases from left to right or from top to bottom. In a d.c. circuit the positive-pole fuse shall be on the left, at top, or closer to reach.

4.6.4.15 The manual actuators of voltage regulators installed in main or emergency switchboards shall be positioned close to the measuring instruments associated with the respective generators.

4.6.4.16 The ammeters of direct current compound generators intended for operation in parallel shall be included in the hole circuit not connected to the common wire.

4.6.4.17 For connecting portable and semi-portable instruments, flexible-stranded conductors shall be used.

4.6.4.18 Switch electrical apparatus controls, panels and outgoing circuits on the switchboards shall have their designations marked. The apparatus switching positions shall be also indicated.

Besides, markings shall be provided to indicate the rated currents of the installed safety devices and switches, settings of circuit breakers and electrothermal trips.

4.6.4.19 Each outgoing circuit in a switchboard shall be provided with an appropriate circuit breaker to disconnect all poles and phases.

Switches or circuit breakers may be dispensed with in lighting branch boxes provided with a common switch and also in the circuits of instruments interlocking devices, alarms and local lighting of switchboards protected by fuses.

4.6.5 Light signals.

4.6.5.1 Light signals shall be of the colour specified in Table 4.6.5.1.

Table 4.6.5.1

Colour	General meaning	Type of signal	Condition of device
Red	Danger	Blinking	Alarm in dangerous conditions where immediate action is necessary
		Permanent	Alarm in dangerous conditions,detected, but not yet rectified
Yellow	Attention	Blinking	Abnormal conditions where immediate action is not required
		Permanent	Intermediate condition between abnormality and safety Abnormal condition already detected, but not yet rectified
Green	Safety	Blinking	Standby machinery is put into operation
		Permanent	Rated conditions of running and operation
Blue	Information	Permanent	Machinery and gear are ready to be started Voltage in mains. Everything is in order

White	General information	Permanent	Signals switched on when necessary Notations relating to automatic control conditions Other auxiliary signals

4.6.5.2 The use of letters as light signals is acceptable on condition that letters clearly identify the condition of device.

4.6.6 Arrangement of distribution gear.

4.6.6.1 The switchboards shall be placed in locations where the possible concentration of gases, water vapours, dust and acid evaporations is eliminated.

4.6.6.2 If the switchboard having protective enclosure of IP10 type and below is located in a special space, cabinet or recess, then such spaces shall be made of non-combustible material or shall have a lining of such material.

4.6.6.3 Arrangement of pipelines and tanks near the switchboards shall conform to the requirements of **5.5**, Part VIII "Systems and Piping".

4.6.6.4 The navigation lights switchboard shall be located in the wheelhouse where it is readily accessible and visible to the personnel on watch.

4.6.6.5 The main switchboard and generating sets shall be positioned in close proximity to each other, in the same engine room and within the boundaries of the same "A-60" class vertical and horizontal fire-resistant constructions.

The enclosure situated within the main boundaries of machinery space, provided for the main machinery control room where the main switchboard is positioned, is not considered as separating the main switchboard from the generating sets.

Where essential services for stearing and propulsion of ship are supplied from section switchboards these switchboards and any transformers, converters and similar equipment forming the essential part of the system supplying these services shall be also positioned in the same space as generating sets.

4.6.7 Access to switchboards.

4.6.7.1 In front of the switchboard, a passageway shall be provided not less than 800 mm wide for switchboards up to 3 m long, and not less than 1000 mm wide for switchboards 3 m long and over.

In ships of less than 500 gross tonnage, the width of the passageway may be reduced to 600 mm.

4.6.7.2 Behind the free standing switchboards, it is necessary to provide a passageway not less than 600 mm wide for switch boards up to 3 m in length and not less than 800 mm wide, for longer switchboards.

Between the free standing switchboards with open live parts located in special electrical spaces a passageway shall not be less than 1000 mm wide.

4.6.7.3 The space behind the free standing switchboards with open live parts shall be enclosed and fitted with doors in accordance with **2.8.1**.

4.6.7.4 For switchboards more than 3 m in length mentioned in **4.6.7.3** at least two doors shall be provided leading from the space where the switchboard is installed to the space behind the switchboard.

These doors shall be as widely spaced as possible. It is allowed that one of these doors shall lead to the adjacent space having at least another exit.

4.6.7.5 Passageways specified in **4.6.7.1** and **4.6.7.2** are measured from the most protruding parts of apparatus and structure of the switchboard to the protruding parts of equipment or hull structures.

5. ELECTRIC DRIVES FOR SHIPBOARD MECHANISMS AND EQUIPMENT

5.1 GENERAL

5.1.1 The control stations of the drives shall meet the relevant requirements of Part VII "Machinery Installations", while the power supply of electrical (electronic) automation systems shall meet the requirements specified in Part XV "Automation".

5.1.2 Electrically-driven mechanisms shall be provided with light signals to indicate switching-on of the electric drive.

5.1.3 Equipment provided with automatic, remote and local control shall be so designed that the automatic control is switched off as well as the remote control when the change-over to the local control occurs.

The local control shall be independent both of the automatic and remote control.

5.2 INTERLOCKING OF MACHINERY OPERATION

5.2.1 The machinery provided with electric and manual drives shall be fitted with an interlocking device that will prevent simultaneous operation of the drives.

5.2.2 If the machinery is required to operate in a certain sequence, appropriate interlocking devices shall be used.

5.2.3 A device may be installed that will switch off the interlocking on condition that this device is protected from switching off the interlocking inadvertently. Informative inscription shall be placed in close proximity to this device that will indicate its application and forbid its use by unauthorized personnel.

Such a device is not permitted for machinery specified in **5.2.1**.

5.2.4 Starting of the machinery, which electric motors or switchgear require additional ventilation in normal operation, shall be possible only with ventilation in action.

5.3 SAFETY ISOLATION DEVICES

5.3.1 Control systems of mechanisms, which operation under certain conditions may endanger human or ships safety, shall be provided with push-buttons or other safety isolation devices that will ensure disconnection of the electric drive from the power supply.

These push-buttons and/or other safety isolation devices shall be suitably protected against inadvertent actuation.

5.3.2 Push-buttons or other safety isolation devices shall be located near the control stations or in other places with a view to ensure safety of operation.

5.3.3 Electric drives of arrangements and machinery which require restriction of motion to prevent damage or break-down shall be provided with terminal switches to ensure reliable isolation of the electric motor.

5.4 SWITCHGEAR AND CONTROL GEAR

5.4.1 The switchgear in the circuits of electric drives, which in itself does not provide for shortcircuit protection shall withstand the short-circuit current that may flow at the point of its installation during the time required for operation of a special protection device.

5.4.2 Starting of the engine shall be possible only from the zero position of the control gear.

5.4.3 A discharge protection device shall be provided for the control gear that permits isolation of the shunt-field windings.

5.4.4 For directly started alternating-current electric motors, the requirements of **3.1.2.3** and **16.8.3.3** shall be taken into consideration.

5.4.5 For each electric motor rated at 0,5 kW and more and its control gear, provision shall be made for fitting a device to isolate the power supply.

If the control gear is mounted on the main switchboard or on any other switchboard in the same compartment and its visibility is ensured from the place of installation of the electric motor, then for this purpose it is permitted to use a switch mounted on the switchboard.

If the requirements in respect of location of machine control gear stated above are not met, the following shall be provided:

.1 a device interlocking the switch on the switchboard in the "off" position; or

.2 an additional disconnecting switch near the electric motor; or

.3 fuses in each pole or phase of the control gear arranged in such a manner that they could be readily removed or replaced by the personnel.

5.5 ELECTRIC DRIVES AND CONTROL OF STEERING GEAR

5.5.1 In addition to the requirements of **6.2**, Part IX "Machinery", **2.9**, Part III "Equipment, Arrangements and Outfit", steering gear shall comply with the requirements of this Part of the Rules.

5.5.2 Main electric or electro-hydraulic steering gear comprising one or more power units shall be supplied by two separate feeders laid directly from the main switchboard in two different runs (refer also to **16.8.4.12**).

One of these feeders may be supplied through the emergency switchboard. When the collecting busbars in the main switchboard are subdivided, each feeder shall be supplied from different sections (refer also to **4.3.2**).

In case the auxiliary electric or electro-hydraulic steering gear is provided according to **2.9**, Part III "Equipment, Arrangements and Outfit", it may be supplied from the feeders of the main electric steering gear.

5.5.3 Each feeder shall be selected so as to supply all the electric motors, which are normally connected thereto and operate simultaneously.

5.5.4 If a change-over arrangement is provided to supply any electric motor or a combination of motors from one or the other feeders, such feeders shall be designed for operation under the most severe loads, and the change-over arrangement shall be installed in the steering gear compartment.

5.5.5 In case a steering gear power unit becomes inoperative, another unit required by 2.9.4, Part III "Equipment, Arrangements and Outfit" shall be actuated manually from the bridge control station. Provision may be made for an additional automatic actuation of the power unit.

5.5.6 In every ship provided with steering gear according to 2.9.6, Part III "Equipment, Arrangements and Outfit" in the event of failure of the main source of electric power of the steering gear power unit provision shall be made for automatic connection within 45 s to the emergency source of electrical power or an other independent source located in the steering gear compartment and intended only for this purpose.

For ships of 10000 gross tonnage and over the power of this source shall be sufficient for continuous supply of the steering gear, associated control system and rudder angle indicators within at least 30 min and for all other ships, within at least 10 min.

5.5.7 The operating conditions for the electric motors of the drives for the active means of the ship's steering shall conform to the conditions prescribed for the entire gear, but the motors shall at least satisfy the short-term operating conditions during not less than 30 min.

5.5.8 The electric or electrohydraulic drive of a steering gear shall ensure:

.1 putting the rudder from hard over to hard over within the time and angle stated in **6.2.2**, Part IX "Machinery";

.2 putting the rudder continuously from hard over to hard over during 30 min for each set at the maximum service speed ahead corresponding to the draught at which the rudder is fully immersed (refer also to **2.9.2** and **2.9.3**, Part III "Equipment, Arrangements and Outfit");

.3 continuous operation during one hour at the maximum service speed ahead with putting the rudder over through an angle so as to ensure 350 puttings over per hour;

.4 possible stalling of the electric motor in "on" position for one minute from hot state (only for rudders fitted with the direct electric drive);

.5 sufficient strength of electric drive in the presence of mechanical forces arising at maximum speed astern. It is recommended that a possibility shall be provided for putting the rudder over at the average speed astern.

5.5.9 Starting and stopping of the steering gear electric motors, other than electric motors of rudders with direct electric drive, shall be effected from the steering room and from the wheelhouse.

5.5.10 The starting devices shall ensure automatic restarting of electric motors as soon as the voltage is restored after a discontinuity in power supply.

5.5.11 Visual and audible alarm shall be initiated on the navigation bridge in case of:

.1 power supply failure of each power unit, the control system, as well as the earth faults;

.2 несправності в системах керування із зворотним зв’язком, включаючи:

.2.1 short circuit, broken connections, earth faults in command and feedback loops;

.2.2 data communication errors, computer hardware and software failures (if programmable electronic systems are used);

.3 low oil level in any tank of the hydraulic system.

.4 hydraulic locking.

Besides, means shall be provided to indicate operation of electric motors of the steering gear power units.

5.5.12 Alternatively to alarm specified in **5.5.11.2**, critical deviations between rudder order and reply may be indicated visually and audibly as steering failure alarm on the navigation bridge. The following parameters shall be monitored:

.1 actual rudder position following the set value;

.2 rudder's actual position reaching set position within acceptable time limits;

.3 difference between the actual and set ruder position (refer to 2.9.15, Part III "Equipment, Arrangement and Outfit").

5.5.13 The following visual and audible alarm shall be provided at the main machinery control room:

.1 loss of voltage, phase break-off;

.2 power supply circuit overload of each power unit;

.3 low oil level in any tank of the hydraulic system. Besides, means shall be provided to indicate operation of electric motors of the steering gear power units.

5.5.14 The steering gear control systems specified in **2.9.13** and **2.9.14**, Part III "Equipment, Arrangements and Outfit" shall be supplied by separate feeders laid in different runs from the power circuits of the steering gear in the steering gear compartment or directly from the busbars of the switchboard serving these power circuits.

5.5.15 In the steering gear compartment means shall be provided for disconnecting any bridge control system from the steering gear it serves.

5.5.16 Each remote control system specified in **2.9.13** and **2.9.14**, Part III "Equipment, Arrangements and Outfit" shall have its own independent circuit, including all electrical components, for transmission of orders to the steering gear actuator and shall be so arranged that a mechanical or electrical failure in one of them will not render the other one inoperative.

Wires, terminals and the components for duplicated steering gear control systems installed in units, control boxes, switchboards or bridge consoles, as well as circuits of common switching units of control systems, shall be separated as far as practicable or separated by means of a fire retardant plate.

5.5.17 In the case of double follow-up control, the amplifiers shall be electrically and mechanically separated.

In the case of non-follow-up control and follow-up control, it shall be ensured that the follow-up amplifiers are protected selectively.

Therewith, selectivity of protection devices actuation shall be ensured.

5.5.18 Where additional control systems are provided, their control circuits shall be designed for allpole disconnection.

5.5.19 Feed-back units and limit switches for the steering gear control systems shall be separated electrically and mechanically connected to the rudder stock or actuator separately.

5.5.20 Any of the most probable failures (loss of power or failure in feedback control systems) shall not result in the complete loss of steering capability.

5.5.21 The direction of rotation of the rudder wheel or the direction of motion of the control gear handle shall agree with the direction of putting the rudder over.

In the push-button control system, the push-buttons shall be arranged in such a manner that the switching on of the push-button located to the right causes the rudder blade to move rightward, while the button to the left its motion leftward.

5.6 ELECTRIC DRIVES OF ANCHOR AND MOORING MACHINERY

5.6.1 In addition to the requirements of **6.3** and **6.4**, Part IX "Machinery", the drives of windlasses, anchor and mooring capstans and mooring winches shall comply with this Part of the Rules.

5.6.2 Electric drives of anchor and mooring machinery shall ensure possible stalling. Duration of stalling shall be limited by the activating time of overload protection or winding temperature protection, but not exceeding 30 s for anchor machinery and 15 s for mooring machinery.

5.6.3 In anchor and mooring capstans and mooring winches at the speed steps intended only for mooring operations provision shall be made for overload protection of the electric motor.

5.6.4 The supply of electric drives of anchor capstans shall be effected in conformity with **4.3.1** and **4.3.3**.

5.7 ELECTRIC DRIVES OF PUMPS

5.7.1 The electric motors of fuel and oil transfer pumps and separators as well as of organic coolant circulation pumps shall be provided with remote disconnecting switches located outside the space wherein these pumps are placed and outside the machinery casings, but in close vicinity of the exits from these spaces.

5.7.2 The electric motors of the pumps transferring the liquids overboard through the drain holes above the lightest waterline at locations where lifeboats or liferafts are lowered shall be provided with disconnecting switches located near the control stations of the driving machinery for lowering the relevant boats or rafts.

5.7.3 The electric motors of emergency fire pumps and submersible bilge pumps shall be provided with remote starting devices located above the bulkhead deck (refer to **3.2.3.9**, Part VI "Fire Protection").

A remote starting device shall be provided with a light signal indicating the "on" condition of the electric drive.

5.7.4 Disconnecting switches of electric drives specified in **5.7.1** shall be located in conspicuous positions covered with glass and provided with explanatory inscriptions. The disconnecting switches shall de-energize feeders of those electric drives.

5.7.5 Local starting of fire and bilge pumps shall be possible even in case of failure of their remote control circuits, including protection equipment (refer also to **6.6.8.3**, Part VI "Fire Protection").

5.7.6 The electric motors of oily and sewage water transfer and discharge pumps shall be provided with remote cut-off arrangements located in the vicinity of discharge manifolds, provided no telephone or radio communication is available between the discharge observation position and discharge control position.

5.8 ELECTRIC DRIVES OF FANS

5.8.1 The electric motors of ventilation fans in machinery spaces shall be provided with at least two disconnecting switches, one of which shall be located outside these spaces and their casings, but in close vicinity of the exits from these spaces.

It is recommended that these disconnecting switches be positioned together with similar switches referred to in **5.7.1**.

5.8.2 The electric motors of ventilation fans of cargo holds and galley fans shall be provided with disconnecting switches at locations readily accessible from the main deck, but outside the machinery casings.

Electric motors of exhaust ventilation from galley ranges shall be provided with a disconnecting switch located inside the galley, regardless of the number of disconnecting switches.

5.8.3 The electric motors for general shipboard ventilation shall have at least two switches for remote disconnection of the motors, one of the switches being fitted in the wheelhouse and the other located at an easily accessible position outside the space being served. This position shall not be readily cut off in the event of a fire in the spaces served.

For ships with electrical installation of low power (other than passenger ships) it is permitted to use one disconnecting switch.

5.8.4 The electric motors of fans in the spaces protected by a smothering system shall be provided with a disconnecting switch operating automatically when fire extinguishing medium is discharged into the space.

When such spaces are fitted with fire closing appliances that automatically block air access therein, the manual switching off the fans may be permitted; therewith, the disconnecting switches shall be located outside the above spaces.

5.8.5 The disconnecting switches of the electric motors of fans listed in **5.8.1** to **5.8.3** shall be so grouped on board the ship that all these electric motors could be stopped from not more than three positions.

The disconnecting switches shall de-energize feeders of those electric motors of fans.

5.9 ELECTRIC DRIVES OF BOAT WINCHES

5.9.1 The electric drives of boat winches shall comply with the requirements of 6.20, Part II "LifeSaving Appliances" of the Rules for the Equipment of Sea-Going Ships.

5.9.2 The winch electric drive controls shall be provided with self-return to the "stop" position.

5.9.3 A switch in power circuit of the electric motor shall be installed near the boat winch control station.

5.9.4 On standby vessels emergency source of power of electric drives of boat winches shall provide the operation of electric drives of boat winches for at least 4 hours.

5.10 ELECTRIC DRIVES OF WATERTIGHT AND FIRE DOORS

5.10.1 The electric drives of watertight doors shall meet the requirements of 7.12, Part III "Equipment, Arrangements and Outfit".

5.10.2 Power supply of electric drives and indicators of position and closure of the watertight doors shall be taken from the main, emergency and emergency intermediate sources of electrical power in accordance with **4.3.1**, **9.3** and **19.1.2**.

5.10.3 As far as practicable, electrical equipment and components for watertight doors shall be situated above the bulkhead deck and outside dangerous areas and spaces.

5.10.4 Suitable protection from water penetration shall be provided for the enclosures of the following electrical equipment positioned perforce below the bulkhead deck:

.1 electric motors and control equipment circuits related thereto - IPX7;

.2 door position indicator sensors and circuit elements related thereto - IPX8;

.3 door movement audible alarm elements - IPX6.

5.10.5 Electric power, control, indication and alarm circuits shall be protected against fault in such a way that a failure in one door circuit will not cause a failure in any other door circuit.

Short circuits or other faults in the alarm or indicator circuits of a door shall not result in a damage in the electric power and control circuits.

Arrangements shall be such that leakage of water into the electrical equipment located below the bulkhead deck will not cause the door to open.

5.10.6 A single failure in the power operating or control circuits of a sliding watertight door shall not result in a closed door opening. Availability of the power supply shall be continuously monitored in the immediate vicinity of each of the motors required by **7.12.5.7**, Part III "Equipment, Arrangements, and Outfit".

Loss of power supply in the power operating and control circuits shall activate an audible and visual alarm in the main machinery control room and at the navigation bridge.

5.10.7 The electric drives of devices for holding the fire doors in the open position (refer to **2.1.3.4**, Part VI "Fire Protection") shall:

.1 be supplied from the main and emergency sources of electrical power;

.2 be remotely controlled from the wheelhouse for closing the doors individually, in groups or all doors simultaneously;

.3 automatically close all the doors simultaneously in case of the supply voltage loss;

.4 be so designed that any damage in the mechanism of closing any door could not render inoperative the systems of supply and operation of other doors.

5.11 ELECTRIC DRIVES FOR OIL BURNER UNITS OF BOILERS AND INCINERATORS

5.11.1 Electric drives for oil burner units of boilers and incinerators shall be provided with remote shut off devices located outside the spaces where they are installed (refer also to **5.3.8**, Part X "Boilers, Heat Exchangers and Pressure Vessels" and **4.3.6**, **4.10.3.4** and **6.2.3**, Part XV "Automation").

5.11.2 Where the spaces in which the incinerators and boilers are installed are protected by aerosol fire-extinguishing system, the electric drives for oil burner units of boilers and incinerators shall be automatically shut off when the said system is activated.

5.12 ELECTRIC DRIVES OF DEWATERING ARRANGEMENTS OF FORWARD SPACES OF BULK CARRIERS

5.12.1 In addition to the requirements of **7.9.**2 and **7.9.3**, Part VIII "Systems and Piping", electric drives of dewatering arrangements of forward spaces of bulk carriers shall meet the requirements of this Part.

5.12.2 Positive indication shall be provided at the navigation bridge or other station complying with the requirements of **7.9.2**, Part VIII "Systems and Piping" to show that the valve is fully open or closed.

5.12.3 The enclosures of electrical equipment for the dewatering system installed in any of the forward dry spaces shall provide protection to not lower than IPX8 standard for a water head equal to the height of the space in which the electrical equipment is installed for a time duration of at least 24 h.

5.13 ELECTRICAL EQUIPMENT OF ANCHOR HANDLING WINCHES

5.13.1 In addition to the requirements of **6.3**, **6.5**, of Part IX, "MACHINERY", anchor handling winches shall satisfy the requirements of this Part.

5.13.2 Anchor handling winches shall be controlled from control stations, from where sufficient visibility of winch drums is provided.

Controllers shall provide control by one operator, simple actions, while the selected control mode shall clearly differ from other stipulated modes. In case of the control system failure, the device shall be brought to safe condition.

5.13.3 Anchor handling winch shall be controlled both in the anchors hoisting and dropping modes.

5.13.4 Information on the cable tension in accordance with **8.11.2**, of Part III "Equipment, arrangements and outfit", as well as information on the maximum permissible cable tension, the corresponding vertical and horizontal angles defining its position according to calculations made for each load case. This information may be duplicated at the ship control station.

5.13.5 Controls (handles, buttons, etc.) for emergency disconnection shall be protected from unintentional actions of personnel.

6. LIGHTING

6.1 GENERAL

6.1.1 In all ship's spaces, places and zones where the illumination is essential for safety of navigation, control of machinery and gear, habitability and evacuation of passengers and crew, pilot embarkation and disembarkation stationary main lighting fixtures shall be provided, which are supplied from the main source of electrical power.

The list of spaces, places and zones where the emergency lighting fixtures shall be installed in addition to the main ones is given in **9.3.1.1** and **19.1.2.1.1**.

6.1.2 Lighting fixtures installed in spaces and zones where mechanical damage is possible to the glass hoods shall be provided with protection gratings.

6.1.3 Lighting fixtures shall be installed in such a manner as to prevent heating of cables and adjacent materials up to a temperature exceeding the permissible level.

6.1.4 In spaces or spaces illuminated with luminescent lamps where visible rotating parts of machinery are located, all measures shall be taken to prevent stroboscopic effect.

6.1.5 External-illumination lighting fixtures shall be so installed that no light interference with ship's navigation could occur.

6.1.6 In spaces and zones illuminated with discharge lamps, which do not ensure continuity of burning at voltage variations according to 2.1.3, provision shall be also made for lighting fixtures with incandescent lamps.

6.1.7 Battery and other dangerous compartments shall be illuminated with lighting fixtures located in adjacent safe spaces through gastight windows, or with safe-type lighting fixtures located inside the compartment (refer also to **2.9**).

6.1.8 In addition to **6.1.1**, on standby vessels the following rooms and spaces shall be provided with lighting fixtures, supplied from the main and emergency sources of power:

.1 rescue boats storage facilities and their launching, areas for embarkation of recovered people and rescue areas;

.2 outboard spaces in way of rescue area, places for embarkation of recovered people, rescue boats launching;

.3 helideck area and passages to it from places for embarkation of recovered people.

Lighting supplied from an emergency power source shall be operational for at least 30 minutes.

6.2 POWER SUPPLY OF MAIN LIGHTING ELECTRIC CIRCUITS

6.2.1 The switchboards of the main lighting shall be supplied by separate feeders. The main lighting switchboards may supply the electric drives of non-essential services rated up to 0,25 kW and individual cabin heaters rated up to 10 A.

6.2.2 The protective devices of final lighting circuits shall be set to operate at a current rating not exceeding 16 A, the total load current of the consumers connected shall not exceed 80 % of the current setting of the protective device. The number of lighting fixtures supplied by final lighting circuits shall not exceed that specified in Table 6.2.2.

Cabin fans and other appliances may be supplied by final lighting circuits.

Table 6.2.2

Voltage, V	Maximum number of lighting fixtures
Up to 50	10
51 to 120	14
121 to 250	24

6.2.3 Lighting of corridors, machinery spaces, propeller shaft tunnels, boiler water-level indicators shall be supplied by not less than two independent feeders, with the lighting fixtures arranged in such a manner that, even in case of failure of either feeder, as uniform lighting as possible is ensured. These feeders shall be supplied from different distribution boards, which, in case of application of the lighting subdivided busbars in the main switchboard, shall be supplied from different busbar sections. One of the feeders may be that supplying from the emergency switchboard.

For cargo ships with the electrical installation of low power it is allowed that lighting of the above spaces, except for machinery spaces, be supplied by one feeder from the distribution board or from the main switchboard directly.

6.2.4 Local lighting fixtures in accommodation spaces, as well as socket outlets shall take power from the lighting switchboard by a separate feeder, other than that intended for supplying the common lighting fixtures.

6.2.5 If the ship is divided into main fire zones, then lighting of each zone shall be supplied by two feeders supplying the lighting circuits in other fire zones.

The lighting feeders shall be installed, as far as possible, in such a manner that a fire in one zone cannot damage the feeders supplying the lighting circuits in other zones. In case of application of the lighting subdivided busbars in the main switchboard, these feeders shall be supplied from different busbar sections.

6.2.6 The main lighting circuits shall be arranged so that fire or any emergency in the spaces accommodating the main sources of power and/or main lighting transformers, if any, will not cause failure of the emergency lighting.

6.2.7 Permanently installed lighting fixtures in holds shall take power supply from a special switchboard. Apart from the switchgear and protective devices, this switchboard shall be provided with light signals to indicate switching-on of each individual lighting circuit.

For ships with low power electrical installations the lighting fixtures in holds may be supplied from the switchboard located in the wheelhouse; in this case, visual alarm is required on voltage availability in the power supply circuit of lighting fixtures in holds.

6.3 EMERGENCY LIGHTING

6.3.1 The illumination obtained from the emergency lighting fixtures in separate spaces, locations and zones listed in **9.3.1.1** and **19.1.2.1.1** shall at least be equal to 10 % of the general illumination obtained from the main lighting fixtures (refer to **6.7**).

It is permitted that the illumination from the emergency lighting fixtures in the machinery space is equal to 5 % of the main illumination if the socket outlets fed from the emergency lighting circuit are provided. The illumination shall be sufficient to easily find one's way to the means of escape (or shall be equal to 0,5 lx).

6.3.2 To obtain the illumination required in **6.3.1**, the emergency lighting fixtures with incandescent lamps may be combined with luminescent lamps.

6.3.3 The main lighting fixtures are permitted for use as emergency lighting fixtures if they may be also fed from the emergency sources of electrical power.

6.3.4 The emergency lighting circuit shall be so arranged that in case of a fire or other casualty in the spaces containing the emergency sources of electrical power and/or emergency lighting transformers the system of the main lighting will not fail.

6.3.5 For emergency lighting use could be made of the stationary lighting fixtures with built-in accumulators, automatic recharging from the main lighting circuit.

6.3.6 Emergency lighting fixtures or a combined lamp (refer to **6.3.3**) shall be marked in red in visible parts.

6.4 SWITCHES IN LIGHTING CIRCUITS

6.4.1 Two-pole switches shall be used in all lighting circuits.

In dry accommodation and service spaces it is allowed to use single-pole switches in circuits disconnecting individual lighting fixtures or groups of lighting fixtures rated at not more than 6 A and also in lighting fixture circuits designed for safety voltage.

6.4.2 For permanently installed external-illumination lighting fixtures, provision shall be made for switching off all the lighting fixtures from the wheelhouse or from any other permanently watched station on the upper deck.

6.4.3 The switches of lighting circuits of the fire extinction stations shall be located outside these spaces.

6.4.4 The lighting switches behind free-standing switchboards shall be installed near each access door behind the switchboard.

6.4.5 In emergency lighting circuits local switches shall not be used.

The use of local switches is permitted in circuits of such emergency lighting fixtures, which under normal conditions serve as the main lighting fixtures.

A switch shall be provided for emergency lighting in the wheelhouse.

Emergency lighting fixtures of embarkation stations, which under normal conditions serve as main lighting fixtures shall switch on automatically if the ship is de-energized.

6.5 GAS DISCHARGE LAMP INSTALLATIONS

6.5.1 Reactors and capacitors of gas discharge lamp installations shall be protected by securely earthed metal enclosures.

6.5.2 Capacitors of 0,5 mF and over shall be fitted with discharging devices. The discharging device shall be so designed that the voltage of the capacitor does not exceed 50 V in 1 min after disconnection from supply.

6.5.3 Reactors and transformers having a high inductive reactance shall be installed as close as possible to the lighting fixture they serve.

6.5.4 Gas discharge lamp installations supplied at over 250 V shall be provided with warning notices giving the voltage rating. All live parts of such installations shall be suitably protected.

6.6 SOCKET OUTLETS

6.6.1 Socket outlets for portable lighting fixtures shall be installed at least:

1. on deck near the windlass;
2. in the gyrocompass room;
3. in the radio equipment converter room;
4. in the steering gear compartment;
5. in the emergency generator set compartment;
6. in the machinery spaces;
7. behind the main switchboard;
8. in special electrical spaces;
9. in the propeller shaft tunnel;
10. in the wheelhouse;
11. in the radioroom;
12. in the vicinity of winches;
13. in the vicinity of the log and echo-sounder trunk or recess;
14. in spaces where centralized ventilation and air conditioning installations are located.

6.6.2 Socket outlets fed with different voltages shall be so designed as to prevent insertion of a plug intended for one voltage into a socket intended for higher voltage.

6.6.3 Socket outlets for portable lighting and other electric appliances installed on the open decks shall be mounted with their face looking downward.

6.6.4 Socket outlets shall not be fitted in machinery spaces below the plating, in enclosed fuel and oil separator rooms or where approved safety-type equipment is required.

6.7 ILLUMINATION

6.7.1 The illumination of particular spaces and zones shall not be below that specified in Table 6.7.1. This requirement is not applicable to ships provided with lighting circuits supplied at a voltage below 30 V.

The general lighting standards stated in Table 6.7.1 refer to a level of 800 mm above the deck (flooring) of the space, while the standards of general plus local lighting, to the level of working surfaces.

Table 6.7.1

№	Приміщення і поверхні	Illumination, lux			
		Luminescent lighting		Incandescent lighting/LED lamps	
		general+ local	general	general+ local	general
1	**2**	**3**	**4**	**5**	**6**
1	Radio communication station:				
	At the predetermined level above the deck	–	–	–	100
	Operator tables in radio communication station	–	–	200	–
2	Chartroom:				
	At the predetermined level above the deck	–	100	–	50
	Chart tables	150	–	150	–
3	Wheelhouse. At the predetermined level above the deck	–	75	–	50
4	Machinery spaces, spaces for switchboards, manoeuvring and control stations and panels, spaces for automation facilities and gyrocompasses:				
	At the predetermined level above the deck plating	–	75	–	75
	Surfaces of switchgear and control desks	200	100	150	75
	Main engine controls	150	100	150	75
	Passageways between boilers, machinery, ladders, platforms, etc.	–	75	–	30
	In front of boilers	100	75	75	75
5	Battery compartment. At the predetermined level above the deck	–	75	–	50
6	Surfaces of switchgear and control desks:				
	At the predetermined level above the deck	–	50	–	20
	Surfaces of shaft bearings and connection flanges, etc	75	–	50	–
7	Passageways o n decks, gangways and lifeboat and liferaft positions. At the predetermined level above the deck	–	50	–	20
8	Overboard spaces in way of lifeboat and liferafts launching. Near the load waterline	–	–	–	–

6.7.2 In addition to **6.7.1**, on standby vessels the following requirements shall be met:

.1 illumination of outboard spaces within 5 m in way of rescue area, places for embarkation of recovered people, rescue boats launching shall be at least 150 lux of general illumination;

.2 illumination of outboard spaces within 20 m in way of rescue area, places for embarkation of recovered people, rescue boats launching shall be at least 50 lux of general illumination;

.3 a search light, operated from the wheel house shall be provided at each side. Each search light shall provide illumination of at least 50 lux in clear condition over a surface with a diameter of not less than 10 m on the distance not less than 250 m from the ship.

6.8 NAVIGATION LIGHTS

6.8.1 The navigation lights switchboard shall supply by separate feeders the masthead lights, sidelights and sternlight, and in towing, pushing, fishing, pilot vessels, vessels restricted in ability to manoeuvre and air-cushion vehicles it shall supply also permanently mounted lights listed in Table **2.4.1**, Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships, and additional masthead and stern lights listed in Table **5.2.1** of the said Part of the Rules.

6.8.2 The navigation lights switchboard shall be supplied by two feeders:

.1 one feeder from the main switchboard through the emergency switchboard;

.2 the second feeder from the nearest distribution board, which is not supplied from the emergency switchboard.

It is permitted to install the navigation lights control devices in the integrated bridge control console and taking the power in accordance with **4.5.2**.

Where the main source of power of the ship is an accumulator battery and the main switchboard is installed in the wheelhouse, the navigation lights may be controlled directly from the main switchboard.

6.8.3 The power supply of navigation lights shall be of two-wire system with a double-pole switch for each circuit to be installed in the navigation light switchboard.

6.8.4 Each navigation light power supply circuit shall be provided with protection in both wires and with indication of the navigation light switching in compliance with the requirements of 4.1.4, Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships.

The indication device of the navigation light switching shall be so designed and installed that its failure does not cause the navigation light disconnection.

The voltage drop at the distribution board supplying navigation lights including the system of indicating the lights operation shall not exceed 5 % at rated voltage up to 30 V and 3 % at rated voltage above 30 V.

6.8.5 Independent of the navigation light switching indication referred to in **6.8.4**, provision shall be made for visual and audible alarms operating automatically in case of:

.1 failure, including short circuit, of any navigation light with the switch in the "on" position;

.2 failure of power supply to navigation lights switchboard.

Alarms shall be supplied from a source or feeder other than that used for power supply to navigation light switchboard or from an accumulator battery

6.8.6 Independent of the navigation light switching indication referred to in 6.8.5, provision shall be made for visual and audible alarms operating automatically in case of failure of any navigation light with the switch in the "on" position.

Alarms shall be supplied from a source or feeder other than that used for power supply to navigation light switchboard or from an accumulator battery.

6.8.7 Lamp holders and lamps used in navigation lights shall comply with the requirements of **3.1.7**, Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships.

6.9 LIGHTING AND ILLUMINATION MEANS OF HELIDECKS

6.9.1 General.

6.9.1.1 Lighting and illumination means of helidecks shall comply with applicable requirements of Part III “Signal Means” of the Rules for the Equipment of Sea-Going Ships.

6.9.1.2 The lighting and illumination means for helidecks shall at least provide for the following:

indication of the perimeter (boundaries) of the helideck;

illumination of the landing area;

indication of the elevated structures within the landing area.

6.9.1.3 Lights used for this purpose shall be protected to not lower than level IP56 and shall function reliably under environmental effects mentioned in Section **2**.

6.9.1.4 All lighting and illumination means as well as other electrical equipment within helicopter refuelling stations and hangars shall be of certified safe type and designed to not lower than the temperature class T3 and subgroup IIA.

6.9.1.5 In respect to their lighting characteristics and arrangement, the lights shall meet the requirements of ICAO (International Civil Aviation Organization) which shall be confirmed by the appropriate conclusion or by a Certificate of the Civil Aviation competent body.

6.9.1.6 Lighting and illumination equipment specified in this Chapter shall be supplied from a separate switchboard, which is fed by the main and emergency sources of power supply, with automatic switching in case of power loss.

6.9.2 Perimeter lights.

6.9.2.1 Lighting and distinguishing circuit, which indicates the perimeter (boundaries) of a helideck, shall consist of green all-round lanterns (lights) installed along the perimeter of a helideck. Lanterns (lights) shall be positioned at uniform intervals (up to 3 m) along the perimeter of a helideck.

6.9.2.2 For rectangular or square helicopter decks, a minimum number of lights installed on each side of the deck shall be at least 4, including lights installed in each corner.

6.9.2.3 The lights shall be divided into two independent circuits and supplied in such a manner that when the power to any one circuit fails, 50 per cent of lights to indicate the perimeter remain functioning.

6.9.3 Illumination of the landing area.

6.9.3.1 The landing area and wind direction indicator shall be properly illuminated. For this purpose, floodlights may be used.

6.9.3.2 Helideck floodlights shall be located so as to avoid glare to pilots during take-off, landing and maneuvering.

Height of lighting equipment above the helicopter deck level shall not exceed 250 mm.

6.9.4 Obstruction/warning lights.

6.9.4.1 To provide flight safety, all considerably elevated structures and items such as superstructure components, drill and production strings, etc. shall be marked by special obstruction/warning red lights.

6.9.4.2 Lights shall be divided into several independent circuits and supplied in such a manner that when power supply to one of the circuits fails, the basic part of the obsruction/warning lights remains functioning.

7. INTERNAL COMMUNICATION AND SIGNALLING

7.1 ELECTRIC ENGINE ROOM TELEGRAPHS

7.1.1 In addition to the requirements of this Chapter, the engine room telegraphs shall meet the requirements of **3.3.1**, Part VII "Machinery Installations".

7.1.2 Engine room telegraphs shall be provided with visual alarm on voltage availability in the power supply circuit and audible alarm on loss of voltage in the power supply circuit.

7.1.3 Engine room telegraphs installed in the wheelhouse shall be provided with an illuminated dial of regulated illumination.

7.1.4 Engine room telegraphs shall be fed from the main switchboard or from the navigation equipment switchboard. If the ship is provided with the integrated bridge control console the engine room telegraph may be fed from this control console.

7.1.5 The engine room telegraph transmitter shall be so intalled in the wheelhouse that when orders are given out for ship's motion, the telegraph operating handle is shifted in the same direction with the ship.

Vertical position of the handle shall correspond to the "stop" order.

7.1.6 Where engine room telegraphs and devices for remote control of the main engines and the controllable pitch propellers are installed on sloping desks of control panels, the handle in the "stop" position shall be perpendicular to the panel surface and be fixed precisely in this position.

7.1.7 Where two and more engine room telegraphs are located in close proximity to one another (on one deck), they shall ensure the transmission of an order from any telegraph and the reception of order by all of them simultaneously, without additional changing-over.

Change-over to telegraphs located on another deck or in another part of the ship shall be effected with the use of switches fitted on the navigation bridge.

7.1.8 Each engine room telegraph shall be provided with an audible signal arrangement that will ensure the operation of an audible signal on the bridge and transmission of orders and reception thereof in the engine room.

In case of a wrong reply, the operation of the audible signal arrangement shall not stop (refer also to **3.3.1**, Part VII "Machinery Installations").

7.2 INTERNAL SERVICE COMMUNICATION

7.2.1 The system of internal service communication (refer to the requirements below) shall provide a subscriber call and clear voice communication under the normal and emergency ship's operation conditions, as well as under specific noise conditions in places where the communication facilities are installed.

7.2.2 Sound-powered telephones, voice communication facilities, two-way loud-speaking communication facilities, automatic telephone systems or mobile phones of a local network may be used in the system of internal service communication.

7.2.3 The system of internal service communication shall provide voice communication between the wheelhouse and main service spaces and stations. In this case the separate two-way voice communication may be omitted if the communication facility provides at any time the call priority and communications between the wheelhouse and the following main service spaces and stations:

.1 main machinery control room;

.2 local control stations of the main machinery and propellers (for this purpose the two-way telephone communication between the wheelhouse and the main machinery control room with telephones connected in parallel and fitted at local control stations may be used);

.3 radioroom (may be omitted where communication may be established without hardware);

.4 steering gear compartment;

.5 space containing the emergency switchboard;

.6 forecastle and poop stations;

.7 gyrocompass room;

.8 fire smothering station (refer also to **3.1.3.2.6**, Part VI "Fire Protection");

.9 space containing electric propulsion motors;

.10 cargo operations control station (in oil tankers);

.11 fire and rescue control station (in ships with distinguishing mark of provision with means for fire fighting aboard other ships in the class notation);

.12 other spaces where equipment ensuring ship's safe navigation is installed.

7.2.4 Provision shall be made for communications between the main machinery control room or local control stations of the main machinery and propellers and the engineers' accommodations.

7.2.5 For the communication facilities specified in **7.2.3** and **7.2.4**, in addition to sound-powered telephones, provision shall be made for power supply from the main source of electrical power and accumulator battery actuated automatically in case of failure of the main source of electrical power with a capacity sufficient to supply the communication facilities during the time specified in **9.3.1.3** or **19.1.2.1.4**.

7.2.6 The communication facilities between the wheelhouse and the main machinery control room or local control stations of the main machinery and propellers shall include an additional audible and visual alarm to indicate the call both in the main machinery control room and the engine room.

7.2.7 A damage to, or disconnection of one communication facility shall not interfere with the functioning of other communication facilities.

7.2.8 A two-way loudspeaker set may be either autonomous or connected with a command and broadcasting device, which is envisaged by Subchapter **11** of Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.

Loudspeaker system shall comply with the requirements of paragraphs **2.1.3**, **2.1.4** and **6.22.2** of Part II "Live-Saving Appliances" of the Rules for the Equipment of SeaGoing Ships.

7.3 SIGNALLING. GENERAL

7.3.1 The requirements cover the following systems signaling the equipment or ship's condition requiring attention of personnel or passengers, activating an audible and visual alarm

.1 general alarm and fire alarm systems;

.2 fire detection and fire alarm system;

.3 release indication of fire smothering system;

.4 indication of closing of watertight and fire doors and also the doors indicated in **7.12**;

.5 machinery alarm system;

.6 high level of bilge water alarm;

.7 cargo hold water level alarm on bulk carriers, passenger ships carrying 36 persons and more and single-hold cargo ships other than bulk carriers;

.8 engineer's alarm;

.9 personnel alarm, cargo control alarm and alarm of ultimate concentration of dangerously explosive and noxious gases;

.10 side port doors condition alarm;

.11 alarm on presence of people inside refrigerated holds: "Man in hold" alarm (for ships used for processing the living resources of the sea and not engaged in their catching); presence of people inside of refrigeration places or stowage compartments: "Man in room";

.12 sewage holding tanks level alarm;

.13 release indication of fixed local application fire extinguishing system;

.14 bulkhead shaft glands, bearing and pump case temperature alarm system;

.15 maximum permissible cargo temperature alarm system;

.16 overpressure or under pressure in the cargo tanks alarm system;

.17 high- and limit-level alarms in cargo tanks.

.18 high level alarm in the overflow tank of fuel inflow and transfer system;

.19 high level alarm in drainage tanks of fuel system and lubrication oil leakage system;

.20 low level alarm in a service tank of remote valve control system;

.21 gas fuel system signalling and control system;

.22 alarm of maximum permissible water level in drainage wells of cargo holds, which are provided with splash-permeable shields and are located above superstructure decking beyond zones 1 and 2 (see paragraph **7.6.13** of Part VIII "Systems and Piping");

.23 high level alarm of drainage wells of cargo pump rooms of oil tankers;

7.3.2 An opportunity to functionally test each alarm system shall be provided.

Unless otherwise stated, all alarm systems shall be designed on the fail safe principle with provision for power supply failure alarm, alarm on contact-to-frame fault or circuit break, as well as the possibility of checking visual and audible alarms operability.

7.3.3 Audible alarms shall be heard and distinguishable in all the spaces and areas they intended for.

7.3.4 Audible alarms of an alarm system shall be given until their acceptance (acknowledgement) is confirmed, and the visual indication of each separate alarm shall remain until the fault has been corrected.

7.3.5 The sound frequency of audible alarm devices, excepting a bell, shall be within the range of 200 to 2500 Hz.

7.3.6 Where the visual alarm is applied, the colours specified in Table 4.6.5.1 shall be used unless otherwise stated.

7.3.7 The height of inscription text symbols for operating and alarm controls, unless they have been duplicated with symbols/a plate of an established pattern, shall be at least 7 mm, the width is 0,7 symbol height.

This requirement, excepting the visual alarms mentioned in **7.3.1**, also applies to the texts of inscriptions above the controls in switchboards, control consoles, starting, protection and control equipment for electric drives of essential machinery listed in **1.3.2.1.5**.

7.3.8 The texts of inscriptions above operating and alarm controls not mentioned in **7.3.8**, as well as the texts of watch-keeping and other instructions used for the description of a working procedure, starting and control of an object shall have symbols of at least 3,5 mm high, the width is 0,7 symbol height.

7.3.9 Flashing alarms shall emit light within 50 % of the entire work cycle, the pulse frequency therewith shall be within the range of 0,5 to 1,5 Hz.

7.3.10 The control panel shall clearly distinguish between normal, alarm, acknowledged alarm, fault and silenced conditions.

The system shall be arranged to automatically reset to the normal operating condition after alarm and fault conditions are cleared.

7.4 GENERAL ALARM SYSTEM

7.4.1 Ships in which a general alarm given by voice or by any other means cannot be heard simultaneously in all locations where people may be, shall be fitted with electrical general alarm system that will ensure good audibility of signals in all such places.

In addition to the requirements stated below, the general alarm system shall comply with the requirements of 2.1.3 and 6.22.1, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

7.4.2 Sound devices shall be installed in the following places:

.1 in machinery spaces;

.2 in public spaces, if their floor area is more than 150 m^2;

.3 in corridors of accommodation, service and public spaces;

.4 on open decks of passenger ships;

.5 in working spaces.

7.4.3 General alarm system shall be supplied from the ship mains and the busbars of the emergency distribution board in conformity with **9.3.1.3** and **19.1.2.1.4**.

General alarm system may be energized from the ship mains and from an independent accumulator battery if provision is made for an automatic changeover of general alarm circuits to the battery. In this case, no supply either from the emergency source or from an intermediate emergency source of electrical power is necessary.

7.4.4 The general alarm system shall be energized continuously, no matter if the accumulator battery is set in position for charging or discharging.

7.4.5 In case a separate accumulator battery is used for supply of the general alarm system, it may also energize other internal communication and signalling facilities if the battery capacity is sufficient for simultaneous supply of all consumers for at least 3 h and also if these facilities are so designed that a damage to one circuit will not interfere with operation of other circuits provided no longer supply time is required for those facilities.

7.4.6 In circuits supplying the general alarm system the protection only from short circuit shall be provided. Protective devices shall be fitted in both conductors of the feeder and also in circuits of each sound device.

Protection of several sound devices by one common protective device is permitted if in spaces where they are installed good audibility of other sound devices provided with independent protection is ensured.

7.4.7 General alarm sound devices shall be so located that a signal is clearly heard against the noise in the given space.

Sound devices installed in spaces with high intensity of noise shall be fitted with luminous indicators.

The sound of general alarm devices shall differ in tone from the sounds of all other kinds of signalling.

With the exception of bells, audible alarms shall have a sound frequency between 200 and 2500 Hz.

Facilities may be provided for regulating the audible signal frequency within the above limits.

7.4.8 The general alarm system shall be actuated by means of a double-pole switch.

If the general alarm signal is not heard from the wheelhouse or from the station where it has been given, a pilot lamp shall be fitted after the switch to indicate that the general alarm system is activated.

The switches shall be provided with the inscriptions indicating their purpose.

7.4.9 No switching devices shall be incorporated into the circuits of the general alarm system other than the switch specified in **7.4.8**.

Where a power supply switch is installed on the general alarm system switchboard, provision shall be made for its interlocking in the "on" position or it shall be otherwise protected against access thereto of unauthorized persons.

It is permitted to use intermediate contactors controlled by the switch, but not more than one contactor in each loop.

7.4.10 Sound devices, switches and distribution devices of the general alarm system shall be provided with readily visible distinctive symbols.

7.4.11 The general alarm system shall consist of at least two loops controlled by one switch. Shortcircuit protection shall be provided at both poles of each loop of the general alarm system.

7.4.12 Sound devices connected to different loops of the general alarm system shall be fitted in large area spaces (machinery spaces, boiler rooms, fish-processing shops, etc.).

7.5 FIRE DETECTION AND FIRE ALARM SYSTEM

7.5.1 Fire detection and fire alarm systems used on ships shall be of the Register-approved type and, in addition to the requirements of this Chapter, meet the requirements of **4.1.1** and **4.2.1**, Part VI "Fire Protection", the Code for Fire Safety Systems and the Code on Alerts and Indicators (refer to **1.2**, Part VI "Fire Protection").

7.5.2 Application of fire detectors located in spaces where explosive vapours may accumulate or in a flow of air sucked out of these spaces is regulated by **2.9**, **19.2** and **19.3**.

7.5.3 There shall be not less than two sources of power supply for the electrical equipment used in the operation of the fixed fire detection and fire alarm system, one of which shall be an emergency source.

The power of electric supply source shall provide uninterruptible operation of the system with all automatic detectors that have been actuated (see also paragraph **7.5.11.4**).

The supply shall be provided by separate feeders reserved solely for that purpose. Such feeders shall run to an automatic change-over switch situated in or adjacent to the control panel for the fire detection system. Operation of the automatic changeover switch or failure of one of the power supplies shall not result in degradation of the fixed fire detection and fire alarm system.

Where the fixed fire detection and fire alarm system would be degraded by the momentary loss of power, a source of stored energy having adequate capacity according to **9.3.7.3** or **19.1.2.7.3** shall be provided to ensure the continuous operation during changeover between power supplies.

The fixed fire detection and fire alarm system emergency power may be supplied by an accumulator battery or from the emergency switchboard. The emergency source of power shall be sufficient to maintain the operation of the fire detection and fire alarm system for the periods required under **9.3.1.5** or **19.1.2.1.5**, as applicable. At the end of that period, it shall be capable of operating all connected visual and audible fire alarm signals for a period of at least 30 min.

Where the system is supplied from accumulator batteries, they shall be located in or adjacent to the control panel for the fire detection system, or in another location suitable for use in an emergency. The rating of the battery charge unit shall be sufficient to maintain the normal output power supply to the fire detection system while recharging the batteries from a fully discharged condition.

Where the emergency feeder for the electrical equipment used in the operation of the fixed fire detection and fire alarm system is supplied from the emergency switchboard, it shall run from this switchboard to the automatic changeover switch without passing through any other switchboard.

7.5.4 The smoke detection system based on air sampling (refer to **4.2.1.6**, Part VI "Fire Protection") and the fans of this system shall be fed by separate feeders from the main and emergency sources or another independent source of electrical power.

7.5.5 Indicating units of the fire detection and fire alarm system, other than those indicated in 7.5.4.

7.5.5.1 Indicating units of the fire detection and fire alarm system shall have an appropriate design to provide the following:

.1 control over power sources and electric circuits required for system operation, in order to detect power losses and failures, including:

one damage of a supply circuit;

one short circuit of a current-carrying conductor to a metal element of the system;

one short circuit of two currentcarrying conductors.

Failure condition shall initiate visual and sound signals on the control panel, which shall be different from fire signals;

.2 manual confirmation of all alarm signals and system failure signals.

Sound alarm devices may be switched off manually.

Devices that switch off local sound alarms are prohibited for use in living rooms.

.3 clear differentiation of the following system conditions: normal, fire alarm, confirmed fire alarm, system failure signal, mute sound signal;

.4 automatic return to normal operating condition after alarm or failure condition has been cleared.

7.5.5.2 Indicating units of the fire detection and fire alarm system shall be designed in such a manner that:

.1 any signal or damage to one circuit does not influence normal operation of other circuits;

.2 a fire detection signal shall prevail over other signals fed to the indicating unit and to make it possible to determine the location of the space wherefrom this fire detection signal has arrived;

.3 contact-type fire detector circuits are normally closed;

it is permitted to use detectors with normally open circuits if the contacts are hermetically sealed and permanent damage control of the circuits is effected;

.4 provision is made for monitoring its operation.

7.5.6 Indicating units of the fire detection and fire alarm system shall produce information specified in Table7.5.6.

A visual signal of fire detection shall be executed in such a manner that is consists of two indicators (two lamps or a double filament), or a special device shall be provided to check the proper condition of signalling lamps. The colour of a light signal shall comply with the requirements of **4.6.5**.

Visual signals shall be separate for each kind of information.

Table 7.5.6

№	Signalling of operating conditions and faults	Signal of using temperature fire detection and fire alarm system	Signal of using systems, in which air from protected spaces enters indicating units
1	Operation of device	Visual	Visual
2	Power supply from emergency source	Visual	Visual
3	Signals of fire and location of area or space where outbreak of fire is detected	Audible Visual	Audible Visual
4	No draught in detection chamber	–	Audible Visual
5	No draught in pipelines	–	Visual Audible*
6	Disconnection in detector circuits	Visual Audible	–
7	Location of faults in detector circuit	Visual	–
8	Off position of detector circuit*	Visual	–
9	Main power supply failure	Visual Audible	Visual Audible

* Recommended.

Signals intended to determine the location of the space or area wherefrom a pulse has arrived may be common with the signal of fire detection or damage.

Visual signals shall function from the moment a pulse is received till the moment the cause of their operation has been removed; the signal specified in item 1 of Table 7.5.6 shall function continuously.

7.5.7 The fire detection and fire alarm system shall meet the following requirements:

.1 the activation of any automatic detector or manually operated call point shall initiate a visual and audible signals at the control panel and indicating units.

If the signals have not received attention within 2 min, an audible alarm shall be automatically sounded throughout the crew accommodation and service spaces, control stations and machinery spaces of category A.

This alarm sounder need not be an integral part of the fire detection and fire alarm system;

.2 the control panel shall be located on the navigation bridge or in the continuously manned main machinery control room, and in the cargo control room, if any.

One indicating unit shall be located on the navigation bridge if the control panel is located in the main fire control station;

.3 indicating units shall, as a minimum, denote the section in which an automatic detector has activated or manually operated call point has operated;

.4 clear information shall be displayed on or adjacent to each indicating unit about the spaces covered and the location of the sections.

7.5.8 Fire detection and fire alarm systems with a zone address identification capability shall be so arranged that:

.1 no loop shall pass through a space more than once to prevent its damage at more than one point by a fire.

When this is not practical (e.g. for large spaces), the parts of the loop passing through the space for the second time shall be installed at the maximum possible distance from the other parts of the loop;

.2 means are provided to ensure that any fault (e.g. power break, short circuit, earth) occurring in the loop will not render the whole loop ineffective.

It means that a fault occurring in the loop only renders ineffective a part of the loop not being larger than a section of a system without means of remotely identifying each detector (refer also to **2.2.6.5**, Part VI "Fire Protection");

.3 all arrangements are made to enable the initial configuration of the system to be restored in the event of failure (electrical, electronic, informatic);

.4 the first initiated fire alarm will not prevent any other detector to initiate further fire alarms.

7.5.9 The fire detectors containing ionising radiation sources (radioactive isotopes) shall have a certificate confirming their radiation safety issued by a competent body.

7.5.10 Detectors shall meet the following requirements:

.1 automatic detectors shall be operated by heat, smoke or other products of combustion, flame, or any combination of these factors.

The possibility of using automatic detectors operated by other factors indicative of incipient fires may be considered by the Register provided they are no less sensitive than the above detectors.

Flame detectors shall only be used in addition to smoke and heat detectors;

.2 smoke detectors required according to **4.2.1.1**, Part VI "Fire Protection" shall operate before the smoke density exceeds 12,5 % obscuration per metre, but not until the smoke density exceeds 2 % obscuration per metre.

Smoke detectors fitted in machinery spaces of category A shall operate before the smoke density reaches 50 % obscuration per metre;

.3 heat detectors fitted in spaces with a normal air temperature shall operate within the temperature limits of 54 to 78°C when the temperature is increased to those limits at a rate less than 1°C per min.

The Register may consider the possibility of using heat detectors with higher rates of temperature increase taking into account their sensitivity;

.4 the temperature of heat detectors activation in drying rooms and similar spaces, which are characterized by high temperatures, may be set up to 130°C inclusive, and in saunas up to 140°C inclusive;

.5 heat detectors shall reliably operate at a temperature at least by 5°C in excess of the temperature at which the sensor is set;

.6 in machinery spaces of category A the detectors may be used which reveal a seat of fire on appearing temperature pulsation (heat-pulse detectors).

They shall be set to a temperature pulse frequency of 1,9 to 2,3 Hz and above, and operate when an amplitude is exceeded by $(2 \pm 0{,}5)$°C whatever a space temperature may be;

.7 the type of all automatic detectors shall be so chosen that after the operation test they come back to normal operation without any components being replaced.

7.5.11 Sections and their cables shall meet the following requirements:

.1 automatic detectors and manually operated call points shall be grouped into sections;

.2 a section of automatic fire detectors which covers a control station, a service space or an accommodation space shall not cover a machinery space of category A and cargo spaces of ro-ro ships.

In case the fire detection and fire alarm system is fitted with individually identifiable fire detectors, a loop covering sections of automatic fire detectors in accommodation spaces, service spaces and control stations shall not serve machinery spaces of category A and cargo spaces of ro-ro ships;

.3 where the fire detection and fire alarm system is not fitted with individually identifiable fire detectors, no section covering more than one deck within accommodation spaces, service spaces and control stations shall be permitted except the section serving an enclosed stairway.

A number of enclosed spaces served by one section shall not exceed 50.

In case the fire detection and fire alarm system is fitted with individually identifiable fire detectors, the sections may cover several decks and serve any number of enclosed spaces;

.4 cables of sections, including their feeding cables, being part of the system shall be so arranged as to avoid galleys, machinery spaces of category A, and other enclosed spaces of high fire risk except where it is necessary to provide fire detection or fire alarm in such spaces (refer to **16.8.1.8**).

7.5.12 A fire detection and fire alarm system for periodically unattended machinery spaces of category A shall be so designed and the automatic detectors so positioned as to quickly detect the fire in any part of those spaces and under any normal operation conditions of machinery and variations of ventilation.

Except in spaces of restricted height and where their use is especially appropriate, fire detection and fire alarm systems using only thermal detectors shall not be permitted.

The fire detection and fire alarm system shall initiate audible and visual alarms, distinct from those of any other system not indicating fire, in sufficient number of places to ensure that the alarms are heard and observed on the navigation bridge and by a responsible engineer officer.

When the navigation bridge is unmanned, the alarm shall sound in a continuously manned place.

7.5.13 A fire detection and fire alarm system for unattended machinery spaces of category A, as required in **4.2.3**, Part VI "Fire Protection", shall meet the following requirements:

.1 an indicating unit shall be installed on the navigation bridge, in the fire control station or another accessible place protected against fire in a machinery space of category A;

.2 a visual alarm on the indicating unit shall indicate the location (zone) of fire;

.3 a fire alarm shall initiate visual and audible alarms distinct from those of any other system which shall be provided at the locations sufficient to be heard and observed by the watch officer on the navigation bridge and by the responsible engineer officer;

.4 in case of power supply failure or any fault in the system, the audible alarm shall be initiated in addition to the visual alarm;

.5 the type and arrangement of detectors shall ensure quick detection of fire and prevent misoperation under normal conditions of machinery space.

Provision shall be made for detectors of at least two types operating by different factors of fire detection. In spaces of less than 2,5 m in height only the use of heat detectors is permitted;

.6 the arrangement of detector sections shall provide for the indication of fire location. An air movement due to machinery operation shall not affect the efficient operation of the fire detection and fire alarm system;

.7 detectors with controlled sensitivity shall have fixing arrangement and an indicator of the preset sensitivity;

.8 where provision is made for temporarily cutting off an individual detector or a section of detectors, this shall be clearly indicated.

When a preset period of time expires, the switching-off detector or section of detectors shall automatically switch on;

.9 facilities shall be provided to release the fire alarm from the following locations:

.9.1 corridors having entrances to machinery spaces of category A;

.9.2 a wheelhouse;

.9.3 a control station in the machinery space.

7.6 RELEASE INDICATION OF FIRE SMOTHERING SYSTEM

7.6.1 The release indication system shall comply with the requirements of **3.8.3.9** and **4.3**, Part VI "Fire Protection".

7.6.2 The release indication system shall be energized from two independent (main and emergency) sources of power.

An accumulator battery having a capacity sufficient for feeding the system during 30 min may be used as an emergency source of power.

Provision shall be made for automatic change-over of power supply for the release indication system to the emergency source in case of disappearance of voltage from the main source.

7.7 INDICATION OF CLOSING WATERTIGHT AND FIRE DOORS

7.7.1 Indication of closing watertight doors as required in **7.1.9**, **7.1.11**, **7.1.13**, **7.4.1.7**, **7.12.4**, **7.12.5**, **7.12.6** and **7.15**, Part III "Equipment, Arrangements and Outfit" shall meet the following requirements:

1. for all ships at watertight door control stations and in the immediate vicinity, and on both sides of the internal doors for cargo ships the visual indicator system for door position shall be provided.

2. all door shall be provided with an audible alarm, which will sound whenever such a door is closed.

3. the power supply for indicator system of door position and for the alarm system shall be independent of the power supply for operating and closing the doors and shall be provided with a backup power supply from the emergency source of power (e.g. uninterruptible power supply).

7.7.2 Indication of position of fire doors as required in **2.2.3.3**, 2.2.4 and **3.1.2.3**, Part VI "Fire Protection" shall meet the following requirements:

1. at the navigation bridge the visual indicator system for each door position shall be provided;

.2 remote-released sliding doors or power operated doors shall be equipped with an alarm that sounds for not less than 5 s but not more than 10 s before the door begins to move and shall continue sounding until the door is completely closed;

.3 the power supply for indicator system of door position and for the alarm system shall be independent of the power supply for operating and closing the doors and shall be provided with a backup power supply from the emergency source of power (e.g. uninterruptible power supply).

7.8 SOUND SIGNALS IN ENGINEERS' ACCOMMODATION SPACES

7.8.1 1 In the engineers' accommodation spaces the sound signalling system shall be provided for the emergency call of the engineer, which is actuated manually from the main engines control station in the engine room or from the main machinery control room, if any.

7. 9 PERSONNEL ALARM

7.9.1 In ships where engineering watch is maintained by one person, or in ships with unattended machinery space, personnel alarm shall be provided, and in this case:

.1 the alarm system shall monitor safe and efficient condition of the machinery space personnel at least every 30 min;

.2 the alarm signal shall be transmitted to machinery spaces.

If the signal is not acknowledged within 3 min, an appropriate signal shall be transmitted to navigation bridge and to accommodation, service and public spaces where machinery attending personnel might be staying;

.3 the alarm shall be put into operation by personnel attending machinery installation, when one person stays in the machinery space, and shall be disconnected after he leaves the space.

.4 the system shall also meet the requirements in **2.4.1.14**, Part XV "Automation".

7.10 CARGO HOLD WATER LEVEL ALARM SYSTEM ON BULK CARRIERS, PASSENGER SHIPS CARRYING 36 PERSONS AND MORE AND SINGLE-HOLD CARGO SHIPS OTHER THAN BULK CARRIERS

7.10.1 Unless otherwise specified in this Chapter, the cargo hold water level alarm system shall meet the requirements of **7.3** of this Part, as well as **3.4.11**, Part V "Subdivision" and **7.9.9** and **7.6.15** (which is applicable), Part VIII "Systems and Piping".

7.10.2 The alarm system shall provide warning and emergency visual and audible alarms to indicate water level in cargo holds and for the ballast tanks and dry spaces, forward of the collision bulkhead _ only emergency visual and audible alarms.

The warning alarm shall be activated when the water reaches the lower level with the emergency alarm activated when the water reaches the upper level as mentioned in **7.9.9** and **7.6.15** (which is applicable), Part VIII "Systems and Piping".

It is allowed to use one sensor to initiate warning and emergency alarms.

The error in the water level determination by detectors shall not exceed 100 mm.

The warning and emergency audible alarms shall be dissimilar.

The system shall provide clear identification of spaces from which the alarm has been released.

The audible alarm shall be silenced from the alarm panel installed on the navigation bridge.

7.10.3 The alarm system shall be supplied by the main and emergency sources of electrical power. Instead of the emergency source of electrical power an independent, continuously charged from the shipboard charging facility, accumulator battery complying with the requirements for the emergency source of electrical power and capable of supplying the system during at least 18 h may be used. In the event of loss of the main or emergency power and of automatic changeover to the emergency power, an emergency warning alarm shall be released.

7.10.4 The system shall be provided with self-monitoring capability. The alarm signal shall be activated when at least the following faults occur: short circuit, circuit break, contact-to-frame fault. For the computer-based systems, alarm shall be additionally provided to indicate the excess program execution time, central processor fault and input-output unit fault.

The system shall provide a possibility of checking the visible and audible alarms.

7.10.5 Provision shall be made in the system for disabling of the alarm in the events when the cargo holds and forepeak are used as water ballast tanks.

In case where such ballast tanks are emptied, disabling shall be automatically released when the water level lowers below the level of the lowest detector fitted in the hold concerned.

7.10.6 The alarm system components fitted in cargo holds, ballast tanks and dry spaces shall be corrosion-resistant and protected to not lower than IP68 degree of protection and those fitted on open deck _ to not lower than IP56 degree of protection.

7.10.7 Where the alarm system components are fitted in holds intended for the carriage of dangerous goods as well as other goods causing formation of explosive mixtures in the holds, these components and their circuit shall be of intrinsically safe type and protected to not lower than (*Exi*) standard.

7.11 ALARM OF ULTIMATE CONCENTRATION OF DANGEROUSLY EXPLOSIVE AND NOXIOUS GASES

7.11.1 The alarm systems for ultimate concentration of dangerously explosive and noxious gases shall meet the requirements of **9.14.3** and **9.14.4**, Part VIII "Systems and Piping", as well as of **7.2.7**, Part XII "Refrigerating Plants".

7.11.2 The alarm systems for ultimate concentration of dangerously explosive and noxious gases shall initiate audible and visual alarms in the cargo control room, on the navigation bridge and at the analysing unit when the vapour concentration in a given space reaches a pre-set value, which shall not be higher than the equivalent of 30 % of the lower flammable limit.

7.11.3 Alarm system shall be supplied by two power sources, one of them shall be an emergency power source. A separate battery, which is constantly being charged from the ship charger and meets the emergency source requirements, may be used as emergency power source.

7.11.4 The control panel shall be located in the cargo control room, on the navigation bridge, or in a gas safe continuously manned main machinery control room.

Clear information shall be displayed on or adjacent to the control panel to allow the crew to readily determine the source of the alarm or fault condition.

7.11.5 An indicating unit shall be located on the navigation bridge if the control panel is located elsewhere.

7.11.6 The control panel shall have a button or switch to manually reset to normal operating condition after alarm and fault conditions are cleared.

7.11.7 Control panel and indicating unit alarm signals shall be distinct from fault condition signals.

7.11.8 Indicating units may have common alarms servicing multiple sampling points, provided that all sampling points within an alarm group are located in the same space.

7.11.9 Control panels shall have the capability to manually test audible and visual alarms.

7.11.10 Audible and visual alarms shall be initiated on the navigation bridge, at the control panel, and at all indicating units under the following conditions:

.1 upon detection of gas concentrations above the alarm setpoint in any monitored space;

.2 in a fault condition, such as power failure or short-circuit;

.3 low or no flow in any sampling pipe;

.4 tampering with the alarm setpoint; or

.5 failure of any self-test functions in computerized alarm systems.

7.11.11 Computerized systems shall have a self-test function to monitor power supply and volatile memory on start-up and repeated at least once every 24 h.

7.11.12 Audible alarms shall continue until their accepting (quitting) is acknowledged, and visual alarm shall remain in effect while an alarm condition is present.

7.11.13 Electrical components which would reasonably be expected to come into contact with sample gases shall be explosion-proof.

7.11.14 The gas detection equipment shall be so designed that it may readily be tested and calibrated.

7.12 INDICATION OF DOOR POSITION IN RO-RO PASSENGER SHIPS AND RO-RO CARGO SHIPS

7.12.1 Visual and audible alarms shall be installed on the navigation bridge and on each operating panel for closing/opening the doors specified in **7.4**, **7.15**, Part III "Equipment, Arrangements and Outfit" (visor outer bow doors, folding doors, inner bow doors, side shell and stern doors[1]) to provide separate indication of door closed and door fully locked.

The indication panel shall be provided with a lamp test function. The possibility for accidental or unauthorized turning off the indicator light shall be excluded.

7.12.2 The indicator system shall be designed on the fail safe principle and shall include the following:

.1 the indication panels installed on the navigation bridge and at doors' control station shall be provided with:

power supply failure alarm;

earth fault alarm or open-circuit alarm;

a lamp test;

separate indication for door closed, door not closed, door locked and door not locked;

.2 limit switches (door position sensors) closed when the door is closed (when more limit switches are provided for each door they may be connected in series);

.3 limit switches closed when securing arrangements are in place (when more limit switches are provided for each door they may be connected in series);

.4 circuits for the indication of door closed/not closed and for door locked/not locked shall be independent, but may be designed in one multicore cable;

.5 in case of position of limit switches (door position sensors), indication to show: not closed/not locked, securing device is not in place - as appropriate.

7.12.3 The indicator system shall indicate by visual and by audible alarms in the following cases:

.1 if the door is not fully closed, or not fully locked; or

.2 at least one securing device is open or a locking device is unsecured.

7.12.4 The indication panel on the navigation bridge shall be equipped with a mode selection switch "harbour/sea voyage", so arranged that audible alarm is given on the navigation bridge if the vessel leaves harbour with the doors not closed or with any of the securing devices not in the correct position.

7.12.5 The power supply for the indicator system shall be independent of the power supply for operating and closing the doors and shall be provided with a backup power supply from the emergency source of power or any other reliable source (e.g. uninterruptible power supply).

The sensors of the indicator system shall be protected from water, ice formation and mechanical damages, or they shall have respective design resistant to the action of the above factors.

7.12.6 For ro-ro passenger ships, besides the indicator system of door position, provision shall be made of a water leakage detection system with audible alarm and television surveillance, which shall be so arranged as to provide an indication to the navigation bridge and to the main machinery control room of any leakage through inner, side shell and stern doors.

[1]Hereinafter referred to as "the doors"

For ro-ro cargo ships, it is permitted that television surveillance of water leakage through side shell and stern doors is provided from the navigation bridge only.

7.12.7 To control the bow door and the inner bow door position a television surveillance system shall be fitted with a monitor on the navigation bridge and in the main machinery control room.

The system shall monitor the position of the doors and a sufficient number of their securing devices.

Special consideration shall be given for the lighting and contrasting colour of objects under surveillance.

7.12.8 A drainage system (sumps) shall be arranged in the area between the bow door and the ramp, or where no ramp is fitted, between the bow door and inner door.

The system shall be equipped with an audible and visual alarm functions to the navigation bridge for the high water level alarm in the sump or for water level in these areas exceeding 0,5 m, proceeding from the type of structure.

7.12.9 For ro-ro passenger ships engaged in international voyages, the special category spaces and cargo spaces, indicated in **1.5.4.3** and **1.5.9**, Part VI "Fire Protection" (in the absence of continuous patrolling or other effective means of monitoring) shall be monitored by means of television surveillance, so that any movement of vehicles in adverse weather conditions or unauthorized access of passengers thereto, may be detected whilst the ship is moving.

7.13 RELEASE INDICATION OF FIXED LOCAL APPLICATION FIRE EXTINGUISHING SYSTEM

7.13.1 Release indication system shall comply with the requirements specified in **3.12**, Part VI "Fire Protection".

7.13.2 The system shall be equipped with an audible and visual alarm functions regarding release of fire extinguishing system both in the protected space and in permanently manned stations.

Where several fire extinguishing systems are installed the indication system shall clearly indicate the particular system activated.

7.14 TELEVISION SURVEILLANCE AND INDICATION SYSTEM

7.14.1 Television surveillance and indication systems shall comply with the requirements specified in **7.12.6**, **7.12.7**, **7.12.9** of this Part and **7.15.5**, Part III "Equipment, Arrangements and Outfit".

7.14.2 Generally, television surveillance and indication systems shall include the following:

.1 TV cameras;

.2 video displays;

.3 commutation switchboard;

.4 movement detectors;

.5 video recorders.

7.14.3 Television surveillance and indication system shall monitor respective areas and spaces and ensure video transmission to permanently attended control stations. Television surveillance and indication system shall give audible and visual signals when the condition of the monitored item/space is changed.

7.14.4 Television surveillance and indication system shall provide the following alarms:

.1 power failure;

.2 television surveillance and indication system failure;

.3 "TV camera - display" channel failure (short circuit, circuit break);

.4 TV camera(s) failure;

.5 movement detector failure;

.6 video recorder failure.

7.14.5 Television surveillance and indication systems may be of black-and-white or color type. The installation of this or that type depends on the required informative capacity of the system, parameters of the monitored item (location, lighting and other properties) and presumable targets (man, cargo, water and other purposes).

7.14.6 TV cameras transmitting video signals with a "signal/noise" (S/N) ratio not less than 50 dB shall be used in television surveillance and indication systems to minimize the noise on display.

7.14.7 Camera lens projection shall not be less than 480 television lines (tvl) (for color image) or not less than 570 tvl (for black-and-white image).

For digital cameras the lens resolution shall be not less than 10246756 pixels.

7.14.8 Proceeding from their location TV cameras used in television surveillance and indication systems shall be protected to not lower than the following levels:

.1 IP22 - for those fitted in the internal service spaces;

.2 IP44 - for those fitted in machinery spaces;

.3 IP56 - for those fitted on ro-ro decks and exposed parts of the weather deck.

7.14.9 The installation of TV cameras shall be such that all dead zones are covered.

7.14.10 Within internal spaces, TV cameras shall be fitted in places with minimum temperature difference to reduce condensate formation on camera lens.

7.14.11 TV cameras fitted on the exposed part of the deck shall have a thermo-casing with a sun visor.

7.14.12 Where the lighting of monitored area is below TV camera sensitivity, the item (item area) shall be equipped at night-time with additional visible or infra-red lighting.

Therewith, either camera lens shall be not swamped by the lights, or TV cameras with back light compensation (BLC) function shall be used. Where television surveillance and indication system of color type is used, infrared lighting is impermissible.

7.14.13 Displays with a capacity to operate around the clock over a long period of time with a static picture shall be used to display the data received from TV cameras.

The display diagonal for multi-image shall be within 15" - 21" with a resolution not less than 800 tvl for black-and-white image (400 tvl for color image) or within 10" - 14" for full-screen image displays with a resolution not less than 600 tvl for black-and-white image (300 tvl for color image).

7.14.14 Special type video recorders with a capacity to record over long periods of time or digital video data memory shall be used to record TV image.

7.14.15 The recording time for a 180 min videocassette shall not exceed 24 h with the use of specialtype video recorder.

The use of special-type video recorder with a longer recording time is only allowed if the recorder will automatically change over to real-time recording when alarm is activated by the movement detector.

7.14.16 Commutation switchboard shall provide priority display of areas where alarm has been activated.

7.15 SEWAGE HOLDING TANKS LEVEL ALARM

7.15.1 Alarm system shall comply with the requirements of Part III «Requirements for equipment and appliances of ships for the prevention of sewage pollution» of the Rules for the prevention of pollution from ships.

7.15.2 Alarm system shall be supplied from the main source of electrical power.

7.15.3 Alarm system shall produce sound and light signals on permanent watch posts when tank is full at 80 %

7.16 BULKHEAD SHAFT-GLAND, BEARING AND PUMP CASE TEMPERATURE EXCESS ALARM

7.16.1 Bulkhead shaft gland, bearing and pump case temperature excess alarm shall comply with the requirements of 4.2.5, Part VII "Machinery Installations".

7.16.2 Alarm system shall be supplied from the main source of electrical power.

7.16.3 Cargo or pump control station shall be equipped with an audible and visual alarm.

7.17 MAXIMUM PERMISSIBLE CARGO TEMPERATURE EXCESS ALARM

7.17.1 Maximum permissible cargo temperature excess alarm shall meet the requirements of paragraph **9.6.6** of Part VIII “Systems and Piping”.

7.17.2 Alarm system shall be supplied from the main source of electrical power.

7.17.3 Alarm system shall produce sound and light signals on permanent watch posts.

7.18 OVERPRESSURE OR UNDERPRESSURE IN THE CARGO TANKS ALARM SYSTEM

7.18.1 Overpressure or underpressure in the cargo tanks alarm system shall comply with the requirements of **9.7.12**, Part VIII "Systems and Piping".

7.18.2 Alarm system shall be supplied from the main source of electrical power.

7.18.3 Alarm system shall produce sound and light signals on permanent watch posts.

7.19 HIGH- AND LIMIT-LEVEL ALARMS IN CARGO TANKS

7.19.1 High- and limit-level alarms in cargo tanks shall comply with the requirements of **9.11.5**, Part VIII "Systems and Piping".

7.19.2 Alarm system shall be supplied from the main source of the electrical power.

7.19.3 Alarm system shall produce sound and light signals on permanent watch posts when tanks are full at 95 % and 98 % correspondingly.

7.20 HIGH LEVEL IN OVERFLOW TANK OF FUEL INFLOW AND TRANSFER SYSTEM ALARM

7.20.1 High level in overflow tank of fuel inflow and transfer system alarm shall meet the requirements of paragraph **10.3.2** of Part VIII “Systems and Piping”.

7.20.2 Alarm system shall be supplied from the main source of electrical power.

7.20.3 Alarm system shall produce sound and light signals on permanent watch posts when tank is full at 75 per cent filled.

7.21 HIGH LEVEL IN SHIP FUEL SYSTEM DRAINAGE TANK AND/OR LUBRICATION OIL LEAKAGE COLLECTION TANK ALARM

7.21.1 High level in ship fuel system drainage tank and/or lubrication oil leakage collection tank alarm shall meet the requirements of paragraphs 13.5.4 and 14.6 respectively of Part VIII “Systems and Piping”.

7.21.2 Alarm system shall be supplied from the main source of electrical power.

7.21.3 Alarm system shall produce sound and light signals on permanent watch posts when tank is full at 85%.

7.22 PEOPLE PRESENCE INSIDE COOLED ROOMS, STOWAGES AND HOLDS ALARM

7.22.1 People presence inside cooled rooms, stowages and a hold alarm: “A person in a stowage/hold” shall meet the requirements of paragraph **19.10.7** of this Chapter and paragraph **3.3.12** of Part XII “Refrigeration plants”.

7.22.2 Alarm system shall be supplied from the main source of electrical power.

7.22.3 Alarm system shall produce sound and light signals on permanent watch posts.

7.23 MONITORING, CONTROL AND AUTOMATION SYSTEMS WHEN USING NATURAL GAS AS FUEL

7.23.1 General.

7.23.1.1 Monitoring, control and automation systems shall comply with the requirements of Part XV "Automation".

7.23.2 Pressure, level and temperature monitoring.

7.23.2.1 Each gas fuel tank shall be provided with devices for remote monitoring from the bridge and local monitoring of fuel pressure and temperature.

The devices shall be clearly marked with upper and lower range values of allowable working pressure.

Provision shall be made for upper and lower pressure alarms in the tank (where vacuum protection is required by tank design) which shall be activated before safety valve operation.

7.23.2.2 The gas fuel inlet pipe shall be fitted with a device for pressure control between the inlet valve and shore connection.

7.23.2.3 On the gas fuel outlet piping following the pump and on the gas fuel inlet piping following the inlet valve shall be provided with a pressure control device.

7.23.2.4 In the drain well of LNG tank storage space, level indicators and temperature indicating devices shall be fitted. As a result of temperature sensor activation, the main gas valve of the tank shall be automatically closed.

Upper level indicator shall activate an alarm.

7.23.2.5 The LNG tanks shall be provided with level indicators as well as arrangements giving visual and audible lower liquid level signals and ensuring automatic shutdown of motors of fixed and submersible fuel pumps with subsequent visual and audible alarm. Automatic shutdown can be carried out by means of low pressure registration by the pump sensors on a pressure section, drive low current or the lower liquid level. These signals shall be given at the navigation bridge, continuously manned central control station or onboard safety centre.

The liquid level measuring device shall be such that it is possible to obtain a level reading at any time when the LPG fuel tank is in working order. The device (s) shall be suitable for operation in the entire range of design pressure values of the LG fuel tank and in the range of fuel operating temperatures.

If only one level measuring device is provided, it must be maintained in working order without the need to empty the tank or degass it.

Liquid level measuring a devices in a fuel tank for liquefied gas can be of the following types:

- indirect-acting devices that determine the amount of fuel by methods such as weighing or measuring flow rates; or
- closed type appliances which do not penetrate through the walls of the fuel tank in the form of liquefied gas, namely devices using radioisotopes or ultrasonic.

7.23.3 Overflow preventing of gas fuel tanks.

7.23.3.1 The LNG tanks shall be provided with upper level alarm device independent from other liquid level measurement and indication devices and giving sound and light alrm.

Overflow prevention appliances shall be independent from the level control appliances specified in **7.23.2.4**.

7.23.3.2 Each CNG tank shall be provided with means to prevent exceeding the design pressure when receiving fuel and signaling that 95 % of the design pressure has been reached.

7.23.3.3 In addition to the sensors mentioned in **7.23.2** and **7.23.3** an additional sensor shall be provided, operating independently of the upper level alarm device, which shall automatically actuate the safety valve on the fuel bunker line in such a way as to prevent both excess fluid pressure in the bunker line and overflow of the LNG tank.

7.23.3.4 If means of overflow control system shutdown are provided, their unintentional use shall be excluded. Continuous visual indication shall be provided on the bridge, in the CCR with a permanent watch or in the ship's safety center, when using such devices.

7.23.4 Gas leaks control in spaces.

7.23.4.1 ll enclosed gas-dangerous spaces shall be provided with effective gas detection systems in areas of its possible accumulation and leakage.

The number of detectors to be fitted in each space is subject to special consideration in each case with due regard to the size and configuration of the space.

Requirements of **12.14.3**, **12.14.10**, **12.14.13** and **13.12.13**, Part VIII «Systems and Piping» (as applicable) shall be observed**.**

When the gas concentration equal to 20 % of the lower explosion limit is reached in the controlled space, visual and audible alarm is to be given on the bridge. In ventilation ducts containing gas-fuel pipes, the alarm shall be given when the concentration equal to 30 % of the lower explosion limit is reached. If the concentration equal to 40 % of the lower explosion limit is reached, measures (at least those stated in Table 7.23.4.4) to automatically shut down gas-fuel supply to the space shall be taken.

7.23.4.2 In the gas-dangerous machinery spaces, two independent systems are required to control gas supply to the machinery space.

7.23.4.3 In gas-safe machinery spaces at least two detectors of the gas supply control system shall be fitted to activate alarm at reaching 30 % of the lower explosion limi.

7.23.4.4 Where gas-fuel leakage is found and in case of system failure, the safety system shall automatically activate regulating functions stated in Table 7.23.4.4.

Table 7.23.4.4

Monitored parameter	**Alarm**	**Automatic closure of master gas fuel valve** [6]	**Automatic shutdown of gas supply to consumers in machinery space**	**Notes**
1	**2**	**3**	**4**	**5**
Gas detection in gas fuel tank storage room above 20 % LEL[7]	**X**			
Gas detection by two detectors[1] in gas fuel tank storage room above 40 % LEL	**X**	**X**		
Fire detection in gas fuel tank storage room	**X**			
Fire detection in ventilation duct of the fuel storage system located below deck	**X**			
Bilge well high level in gas fuel tank storage room	**X**			
Bilge well low temperature in gas fuel tank storage room	**X**	**X**		
Gas detection in the duct between gas fuel tank and machinery space containing gas consumers above 20 % LEL	**X**			
Gas detection by two detectors[1] in the duct between gas fuel tank and machinery space containing gas consumers above 40 % LEL	**X**	**X**[2]		
Gas detection in gas compressor room above 20 % LEL	**X**			
Gas detection by one of two detectors[1] in gas compressor room above 40 % LEL	**X**	**X**[2]		
Gas detection in the duct inside machinery space containing gas consumers above 30 % LEL	**X**			If double pipes are provided for gas supply to consumers
Gas detection by two detectors1 in a duct inside machinery space containing gas consumers above 40 % LEL	**X**		**X**[3]	If double pipes are provided for gas supply to consumers
Gas detection in ESD protected machinery space[10] , containing gas consumers above 20 % LEL	**X**			
Gas detection by one of two detectors[1] in in ESD protected machinery space containing gas consumers above 40% LEL	**X**		**X**	The non-explosion proof equipment in the machinery spaces with gas consumers shall be also disconnected

Loss of ventilation in the duct between tank and machinery space containing gas consumers	**X**		**X**[2]	
Loss of ventilation in the duct inside machinery space containing gas consumers [5]	**X**		**X**[3]	If double pipes are provided for gas supply to consumers
Loss of ventilation in in ESD protected machinery space containing gas consumers	**X**		**X**	
Fire detection in machinery space containing gas consumers	**X**			
Abnormal gas pressure in gas supply pipe	**X**		**X**[8]	
Failure in valve control system	**X**		**X**[4,9]	Time delay as found necessary
Automatic shutdown of engine (engine failure)	**X**		**X**[4,9]	
Emergency shutdown of engine (manually or by operator)	**X**		**X**	

[1] Two independent gas detectors located close to each other are required for redundancy reasons. If gas detectors are of self-monitoring type, the installation of a single gas detector is permitted.

[2] If the gas fuel tank is supplying gas to more than one consumer and different supply pipes are completely separated and fitted in separate ducts with an individual master valve fitted outside of the duct, only the master valve leading into the duct where gas or loss of ventilation is detected shall close.

[3] If the gas fuel is supplied to more than one consumer and different supply pipes are completely separated and fitted in separate ducts with an individual master valve fitted outside of the duct and machinery space, only the master valve leading into the duct where gas or loss of ventilation is detected shall close.

[4] Only the double shut-off valve with the drain valve is closed.

[5] If the duct is protected by inert gas (refer to **12.11.2**, Part VIII «Systems and Piping» of these Rules), then loss of inert gas pressure shall lead to the same actions, as specified in this table.

[6] Valves specified in **13.12.4.1**, Part VIII Systems and Piping

[7] ELL –explosion lower limit.

[8] This parameter shall not lead to shutdown of gas supply for single-fuel gas engines. Applicable for dual-fuel gas engines only.

[9] Only for the case of 3 valves activation, as specified in **12.11.5**, Part VIII «Systems and Piping» of these Rules.

[10] ESD – hazardous equipment (ignition sources) emergency shutdown devices.

7.23.5 Ventilation capacity monitoring.

7.23.5.1 Any loss of the required ventilating capacity shall give an audible and visual alarm on the navigation bridge or in a continuously manned central control station or safety centre.

7.23.5.2 As acceptable means to monitor the ventilation system capacity the means specified in **12.14.1.11**, Part VIII «Systems and Piping» may be adopted.

7.24 LOW LEVEL IN SERVICE TANKS OF REMOTE VALVES CONTROL HYDRAULIC SYSTEM ALARM

7.24.1 Low level in service tanks of remote valves control hydraulic system alarm shall meet the requirements of **4.1.1.5**, Part VIII “Systems and Piping”.

7.24.2 Alarm system shall be supplied from the main source of electrical power.

7.24.3 Alarm system shall produce sound and light signals on permanent watch posts when low level in tanks reaches 25 per cent or according to the requirements of a particular system.

7.25 MAXIMUM ALLOWABLE LEVEL IN DRANAGE WELLS OF CARGO HOLDS WITH SPLASHPERMEABLE SHIELDS ALARM

7.25.1 Maximum allowable level in drainage wells of cargo holds with splash-permeable shields alarm located above superstructure decking beyond zones 1 and 2 (see paragraph **7.6.13** of Part VIII “Systems and Piping”).

7.25.2 Alarm system shall be supplied from the main source of electrical power.

7.25.3 Alarm system shall produce sound and light signals on permanent watch posts when when maximum permissible water level in drainage wells is reached or according to the requirements of a particular system.

7.26 MAXIMUM ALLOWABLE LEVEL IN DRANAGE WELLS OF OIL TANKERS CARGO PUMPS ROOMS ALARM

7.26.1 Maximum allowable level in drainage wells of oil tankers cargo pump rooms alarm shall meet the requirements of paragraph **7.7.1**, Part VIII “Systems and Piping”.

7.26.2 Alarm system shall be supplied from the main source of electrical power.

7.26.3 Alarm system shall produce sound and light signals on cargo control post and navigating bridge.

8. PROTECTIVE DEVICES

8.1 GENERAL

8.1.1 Outgoing circuits of switchboards shall be protected against short circuits and overloads by means of devices installed at the inception of each circuit.

No overload protection is required for the switchboard power supply if the current consumers supplied from this switchboard have individual protective devices, and the power supply cable is selected on the basis of maximum working current.

8.1.2 Protective devices shall be so adapted to the characteristics of the equipment under protection that they operate under inadmissible overloads and short-circuit currents.

8.1.3 The electric protection system shall be discriminative with regard to both the overload currents and the short-circuit currents.

Such protection system shall be designed so that its operation could not adversely affect the reliable functioning of ship's generating plant and the power supply of essential consumers.

Short-circuit and overload protective devices shall not operate at starting currents of the electrical equipment under protection.

8.1.4 Overload protection shall be provided in:

.1 at least one phase or positive pole in a two-wire system;

.2 at least two phases in an insulated three-wire three-phase current system;

.3 all phases in a three-phase four-wire system.

8.1.5 Short-circuit protection shall be fitted in each insulated pole of a direct-current system or in each phase of an alternating current system.

Short-circuit current protective devices shall be set to operate at not less than 200 % of the rated current of the electrical equipment under protection. Operation of the protective devices may be without time delay or with a time delay necessary for the proper discrimination.

The short-circuit current protective device may be used for the protection of both the electrical equipment itself and its supply cable.

8.1.6 Where cables of reduced cross-sectional area are used in some lengths of power supply circuit, additional protection shall be provided for each of such cables unless the preceding protective device is capable of protecting the cable of reduced cross- sectional area.

8.1.7 Protective devices excluding the possibility of immediate repeated switching after operation of the protection shall not be used in supply circuits of the emergency switchboard, as well as in supply circuits of emergency consumers.

8.1.8 The design of the electronic and computer protection devices of generators and major services shall be such as to ensure easy identification and regulation of their operational settings.

Protection devices shall be equipped with the necessary apparatuses and instruction manuals shall be provided for checking their serviceability and the condition of the settings.

The protection devices of generators and important major services shall be tested once in 5 years to confirm the accuracy of their operation.

8.2 PROTECTION OF GENERATORS

8.2.1 Generators not intended for parallel operation shall be provided with means of protection against overloads and short circuits. Fuses may be used as protective devices for generators rated under 50 kW (kVA).

8.2.2 Generators intended for parallel operation shall be provided at least with the following means of protection:

.1 against overloads;

.2 against short circuits;

.3 against reverse current or reverse power;

.4 against under voltage.

It is necessary that the devices used for generator overload protection shall be provided with light and sound alarms to operate with a time delay of up to 15 min at the loads from 100 to 110 % of the rated current, and shall be capable of disconnecting the generator under protection after a time delay to suit the generator thermal time constant at the loads from 110 to 150 % of the rated current.

It is necessary that for a setting of the protection to operate at 150 % of the rated generator current the time delay shall not exceed 2 min for an alternating-current generator and 15 s for a direct-current generator. An overload exceeding 150 % of the rated current may be allowed where it is required by operating conditions and is admitted by the generator construction.

Overload protection settings and time delay shall be selected to suit the overload characteristics of the generator prime mover so that the prime mover is capable of developing the necessary output within the time delay period adopted.

The protective devices used for generator overload protection shall not prevent the possibility of re-starting the generator immediately.

8.2.3 Automatic and selective disconnect of non-essential services shall be provided in the event of the generator overload. These services shedding may be carried out in one or several steps, depending on the generator overload capacity. Therewith:

.1 the automatic disconnect is not allowed for primary essential services;

.2 the automatic disconnect is allowed for secondary essential services, provided disconnection will not prevent services required for safety being immediately available when the power supply is restored to normal operating conditions;

.3 the automatic disconnect is allowed for services needed for maintaining the minimum comfort habitability conditions for the crew and passengers on the ship.

Examples of such services are as follows:

.3.1 cooking;

.3.2 heating,

.3.3 domestic refrigeration;

.3.4 domestic ventilation drives;

.3.5 sanitary and fresh water, etc.

This requirement may be dispensed with in the case of electrical installations of low power.

8.2.4 Reverse-current and reverse-power protection of generators intended for parallel operation shall be selected to suit characteristics of generator prime mover. The respective protection settings shall be in accordance with those specified in 8.2.4.

Table 8.2.4

Kind of current	**Limits of reverse-current or reverse-power protection settings related to generator prime mover**	
	Turbine	**Internal combustion engine**
Alternating	2-6% of rated output of generator, kW	8-15% of rated output of generator, kW
Direct	2-6% of rated current of generator, A	8-15% of rated current of generator, A

Reverse-power protection for alternating-current generators may be replaced by a different, but not less effective, means of protection. With settings specified in the Table the protection of the types in question shall be activated in 10 s.

Reverse-current protection for direct-current generators shall be installed in the pole opposite to that, in which the equalizer lead is connected.

Reverse-power or reverse-current protection shall still be capable of operation when the voltage applied is reduced by 50 % although reverse current or reverse power may have altered values.

Reverse-current and reverse-power protection shall permit trasfer of power fed from the ship's mains (as, for example, from cargo winches).

8.2.5 Undervoltage protection shall ensure the possibility of a reliable connection of generators to the busbars at a voltage of 85 % or more of rated voltage and shall exclude the possibility of generator-to-busbar connection at a voltage less than 35 % of rated voltage. Besides, it shall disconnect the generators in case of reduction of voltage across its terminals in the range from 70 to 35 % of the rated value.

Undervoltage protection shall operate with a time delay for disconnection of generators from busbars in case of reduction of voltage and shall operate without time delay at the attempt to make connection to the generator busbars before the minimum voltage specified above is reached.

8.2.6 For generators with the ratings of 1000 kVA and above, it is recommended that provision shall be made for protection against internal faults, as well as for the protection of the lead connecting the generator to its switchboard and switch.

Where the generator and its switchboard are installed in different spaces, such protection is compulsory.

8.2.7 If a turbine-driven direct-current generator is intended for operation in parallel, provision shall be made for tripping the circuit breaker of the generator when the automatic safety device of the turbine operates.

8.2.8 The current settings of protective devices with time delay shall be chosen in such a way that in any case a reliable interruption of short-circuit current is ensured after the prescribed time delay.

8.2.9 It is permitted to use safety devices in excitation systems of generators as protective devices for semiconductor elements.

8.3 PROTECTION OF ELECTRIC MOTORS

8.3.1 Outgoing feeders from switchboards supplying electric motors rated at over 0,5 kW shall be provided with means of protection against short-circuit currents and overloads, as well as with novoltage protection if the motor need not be automatically restarted.

It is admissible for overload and no-voltage protective devices to be installed in the motor starting apparatus.

8.3.2 The overload protective devices for continuously running motors shall disconnect the motor under protection when the load is in the range from 105 to 125 % of the rated current.

8.3.3 In supply circuits of fire pump electric drives the overload protective devices operating on the principle of electrothermal and temperature relays shall not be used.

The overload protective devices may be substituted by light and sound alarms.

8.4 STEERING GEAR PROTECTION

8.4.1 Only short-circuit current protection shall be provided for electric motors and control systems of electric or electrohydraulic steering gear.

Light and audible warning shall be provided of the motor overload or of any phase failure of the feeder supplying the motor.

8.4.2 Circuit breakers used to protect direct-current motors against short-circuit currents shall be set for release without time delay at currents not lower than 300 % and not higher than 400 % of the rated current of the motor under protection, while those used with alternating-current motors shall be set for release without time delay at currents not lower than 125 % of the peak starting current of the motor under protection.

In case fuses are used as protective devices the rated current for the fuse links shall be one grade of rating higher than it follows from the values specified for the electric motor starting currents.

8.4.3 For electric motors of the drives for the active means of the ship's steering short-circuit and overload protective devices shall be provided.

Overload protective devices of the above mentioned motors shall be fitted with light and sound alarms to warn of the motor overload and shall disconnect the electric motor over the load range specified in **8.3.2**.

Short-circuit protection shall be in compliance with the requirements of **8.4.2**.

8.4.4 For directly driven electric motors of steering gear, overload protection is permitted for locked rotor periods above 60 s with a setting of not less than twice the full load current of the motor protected.

Where such electric motors obtain their power supply via an electronic converter, e.g. for speed control, and which are limited to full load current are exempt from the requirement to provide overload protection. Alarm at electronic converter overload shall be provided with a setting equivalent to the highest permissible current for the normal operation of steering gear ду.

8.5 PROTECTION OF TRANSFORMERS

8.5.1 Short-circuit and overload protective devices shall be installed on the supply feeders of transformer primaries.

If the supply feeder of the transformer primary is protected against shortcircuit currents only, then the supply feeder of the secondary shall be protected against overload.

Transformers rated up to 6,3 kVA may be protected by fuses only.

No overload protection or alarm is required for voltage transformers and supply transformers of the control circuits.

8.5.2 Where transformers are intended for parallel operation, it is necessary that switches shall be provided to disconnect their primaries and secondaries, but not necessarily at the same time.

If such transformers are fed from different main switchboard sections, which may be isolated in service, provision shall be made for an interlock to preclude their parallel operation in case of main switchboard sections isolation.

8.5.3 The switching-over of instrument current transformers shall be so arranged as to prevent the possibility of their secondary windings being on open circuit.

8.6 PROTECTION OF ACCUMULATOR BATTERIES

8.6.1 Means of protection against short-circuit currents shall be provided for accumulator batteries other than those, which are designed to start internal combustion engines.

8.6.2 Each battery charging system shall be provided with protection against battery discharge due to a drop or loss of the charger output voltage.

8.6.3 For accumulator batteries designed for starting internal combustion engines, it is recommended that disconnectors shall be fitted at the start of the circuit on the accumulator side to disconnect the batteries from services (the disconnector may be fitted in one pole).

8.7 PROTECTION OF PILOT LAMPS, VOLTMETERS, CAPACITORS AND VOLTAGE COILS

8.7.1 Pilot lamps, as well as measuring and recording instruments shall be provided with shortcircuit protection or short-circuit current limiting devices. Pilot lamps may have no short-circuit protection of their own, nor short-circuit current limiting devices, provided that all the conditions specified below are met:

.1 the lamps are enclosed together with the device;

.2 the lamps are supplied from circuits inside the enclosure of the device;

.3 the protection of the circuit of the device is rated for current not exceeding 25 A;

.4 a fault in the lamp circuit is not liable to cause an interruption in the operation of an essential service.

Short-circuit protection or current limiting devices shall be located as close as practicable to the terminals of the device under protection on the supply side.

8.7.2 Radio interference suppression capacitators installed in the circuits of main and emergency switchboards, generators and essential electrical installations shall be protected against short-circuit currents.

Requirements for the protection of capacitators in the systems with electrical power distribution for direct current are specified in **22.4.3**.

8.7.3 The voltage coils of apparatus and devices for control and protection shall be protected against short-circuit current, but they may have no protection of their own, provided that the conditions specified below are met:

.1 the coils are enclosed with the device, are under overall protection and belong to the control system of one device;

.2 the coils are supplied from a device circuit, the protection of which is rated for current not exceeding 25 A.

8.8 PROTECTION OF POWER SEMICONDUCTOR UNITS

8.8.1 Provision shall be made for protecting power semiconductor units from internal and external overvoltage.

8.8.2 Semiconductor element units shall be protected against short circuit. The overload protection of diodes and semiconductors shall be isolated from the overload protection of power circuits.

8.8.3 Where only one consumer is available, a common overload protection is permitted for diode and semiconductors units, and power circuits.

8.8.4 Additional requirements for the protection of semiconductor inverters of an electric drive supplied from d.c. distribution devices are specified in **22.4.3.2**.

8.9 RESIDUAL-CURRENT DEVICES (RCD)

8.9.1 To protect personnel against current injury and to protect some kinds of electrical equipment against single-phase earth fault residual-current devices shall be used.

8.9.2 The residual-current devices shall be fitted in the supply circuits of socket outlets intended to feed the portable equipment and in the supply circuits of cabin's socket outlets as well as the socket outlets in public and other spaces with the voltage in excess of the safe one (50 V).

8.9.3 The residual-current devices shall be set to operate at zero sequence current within 10 to 30 mA.

8.9.4 For essential electrical equipment, installation of the residual-current devices is not permitted.

9. EMERGENCY ELECTRICAL INSTALLATIONS

9.1 GENERAL

9.1.1 In each self-propelled ship, an autonomous emergency source of electrical power shall be provided.

Such source is not required for ships, in which the main sources of electrical power are accumulator batteries, on condition that at least one of the batteries installed satisfies the capacity and location requirements imposed upon the emergency source of electrical power.

9.1.2 A generator or an accumulator battery may be used as an emergency source of power.

9.1.3 The capacity of the emergency source of power shall be sufficient to supply simultaneously all those services that are essential for the safety of navigation in an emergency.

In ships where electrical power is necessary for propulsion, the capacity of the emergency source of electrical power shall be sufficient to restore propulsion to the ship (in conjunction with other machinery, as appropriate) from a dead ship condition within 30 min after blackout.

9.1.4 The possibility shall be provided for functional testing of the complete emergency installation including testing of automatic starting arrangements of the diesel generator.

9.1.5 An indicator shall be mounted in the main machinery control room or on the main switchboard to show when the battery, which serves as an emergency source of electrical power, is being discharged.

9.1.6 The emergency sources of electrical power shall be provided only with short-circuit protection. If the emergency source of power is a generator, in the main machinery control room or in the main switchboard visual and audible alarms shall be fitted to warn of the generator overload.

9.2 SPACES OF EMERGENCY SOURCES OF ELECTRICAL POWER

9.2.1 The spaces of emergency sources of electrical power and of their transformers (if any), of emergency transitional sources of electrical power, emergency distribution switchboard and distribution board of emergency lighting shall be located above the uppermost continuous deck, astern from forepeak bulkhead (collision bulkhead) and be easily accessible from the open deck.

The above mentioned spaces in ships covered by the requirements of Part V "Subdivision" shall be located, as a minimum, at a height of 300 mm above the deepest (damage) waterline.

9.2.2 The arrangement of emergency sources of electrical power and pertinent transformers, if any, of transitional sources of electrical power, emergency distribution board and distribution board of emergency lighting with regard to the main sources of electrical power and pertinent transformers, and with regard to the main distribution board, shall be such that a fire or another emergency in the space of the main source of electrical power, of pertinent transformers, main distribution board or in any machinery space of category A would not hamper the supply, control and distribution of electrical power from the emergency source.

9.2.3 Spaces containing emergency sources of electrical power, pertinent transformers, transitional sources of electrical power, emergency distribution board and distribution board of emergency lighting shall not, where possible, be adjacent to machinery and boiler spaces or to spaces containing the main source of electrical power, pertinent transformers and main distribution board.

In case of adjacent arrangement, the decks and bulkheads separating these spaces shall be constructed in accordance with the requirements of Part VI "Fire Protection" relating to control stations.

9.2.4 Emergency distribution board shall be as close as possible to the emergency source of electrical power.

9.2.5 Where a generator serves as the emergency source of electrical power, the emergency distribution board shall be installed in the same space as the diesel generator except where such an arrangement would adversely affect the distribution board operation.

All starting arrangements, charging facilities and starter accumulator batteries of the emergency unit shall also be installed in this space, provided the requirements of 13.2 are complied with.

9.2.6 The emergency diesel generator space shall be provided with heating appliances to ensure the temperature in the space sufficient for starting, without fail, of the emergency generating set and ventilation in accordance with the requirements of 12.5.3, Part VIII "Systems and Piping".

9.2.7 Where the emergency source of electrical power is an accumulator battery, this battery and the emergency switchboard shall be installed in separate spaces.

The requirements for the battery compartments are given in **13.2**.

9.3 EMERGENCY SOURCES OF ELECTRICAL POWER IN CARGO SHIPS

9.3.1 In cargo ships, the emergency sources of electrical power shall supply the following services:

.1 emergency lighting for:

all corridors, stairways and exits from service spaces as well as passenger lift cars and trunks;

machinery spaces, main generating stations;

all control stations, main and emergency switchboards;

emergency diesel generator space;

wheelhouse;

chartroom and radioroom;

stowage positions for emergency and fireman's outfit and also positions where manual fire alarms are fitted;

steering gear compartments;

positions at fire and sprinkler pumps, emergency bilge pump and starting positions of their motors;

cargo pump rooms;

helicopter hangars and landing areas;

gyrocompass space;

medical rooms;

.2 navigation lights, lights of "Vessel not under command" signal and other lights required by Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships;

.3 internal communication means and general alarm signals;

.4 radio equipment and navigational equipment according to the requirements of Part IV "Radio Equipment" and Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships where the emergency source of power is a diesel generator;

.5 fire detection and alarm systems;

.6 daylight signalling lamps, sound signal means (whistles, gongs, etc.), manual calling and other signals required under emergency conditions;

.7 machinery and devices mentioned under **3.2.1.2**, **3.4.7**, **3.7.3.2.1**, Part VI "Fire Protection";

.8 electric drives of watertight doors with their indicators and alarms;

.9 electric drives of devices holding fire doors;

.10 other systems, the operation of which would be found necessary by the Register to ensure the safety of the ship and the persons on board.

.11 electric drive of the launching appliance for the lifeboat specified in **6.20.4.7**, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

In ships of unrestricted service and restricted area of navigation **R1** of 300 and above gross tonnage, the emergency sources of electrical power shall ensure the supply of services for consumers listed in **9.3.1.1** to **9.3.1.9** during 18 h.

Consumers mentioned under **9.3.1.3** to **9.3.1.6** may be supplied from their own batteries arranged as provided for in **9.2** and having a capacity sufficient to supply those consumers during 18 h.

For ships of gross tonnage 300 and above of restricted areas of navigation **R2**, **R2-S**, **R2-RS,** **R3-S, R3-RS, R3** i **R3-IN** the required period of 18 h may be reduced to 12 h.

For ships of less than 300 gross tonnage, the period of 18 h may be changed to 6 h in the case of unrestricted service and restricted area of navigation **R1** and to 3 h in the case of restricted areas of navigation **R2**, **R2-S**, **R2-RS, R3-S, R3-RS, R3** i **R3-IN**.

9.3.2 The emergency source of electrical power shall ensure, during 3 h, the emergency lighting of muster and embarkation stations for boarding life-saving appliances on deck and overboard according to **2.3.4** and **2.7.7**, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

9.3.3 The supply of steering gear shall be effected from the emergency source of electrical power in accordance with **5.5.6**.

9.3.4 Where a generator is used as the emergency source of electrical power, it shall be:

.1 driven by an internal combustion engine (refer to **2.2.5**, Part IX "Machinery");

.2 automatically started upon failure of the electrical supply from the main source of electrical power monitored at the emergency switchboard busbars and automatically connected to the emergency switchboard, and consumers stipulated under **9.3.1** shall be automatically supplied by the emergency generator.

The total time of starting and load take-over by the generator shall not exceed 45 s;

.3 in case the automatic start of emergency unit stipulated by **9.3.4.2** shall not take place within 45 s, an emergency transitional source of electrical power shall be provided, which shall start immediately on failure of the main source of electrical power.

9.3.5 Where an accumulator battery is used as the emergency source of electrical power, it shall:

.1 operate without recharging with voltage variations across the terminals within 12 % of rated voltage during the whole discharge period, where voltage variations across the terminals of accumulator battery connected to an electronic voltage converter are determined by the permissible range of voltage variation across the terminals of the converter;

.2 be automatically connected to emergency distribution board busbars in case of failure of the main source of electrical power and supply at least the consumers mentioned under **9.3.7** during the time stipulated by **9.3.1** excepting electric drives of fire doors with their indicators and alarms, which can be supplied during 30 min.

9.3.6 As transitional emergency source of electrical power stipulated by **9.3.4.3**, an accumulator battery shall be used, which shall operate without recharging with voltage variations across the terminals within 12 % of rated voltage during the whole discharge period.

Voltage variations across the terminals of accumulator battery connected to an electronic voltage converter are determined by the permissible range of voltage variation across the terminals of the converter, which shall not be above values specified in **2.1.3.1**.

9.3.7 The capacity of the battery serving as the transitional source of electrical power shall be sufficient to supply, during 30 min, the following consumers:

.1 lighting and essential navigating lights according to **9.3.1.1**, **9.3.1.2** and **9.3.2**;

.2 all internal communications and announcing systems required in an emergency;

.3 general alarm system, fire detection and alarm system and warning system on starting a smothering fire-extinguishing system;

.4 daylight signalling lamps, sound signal means (whistles, gongs, etc.);

.5 command broadcast apparatus in accordance with item **12** of Table 2.3.4, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships;

.6 closing gear of watertight doors, their position indicators and signals warning of their closure;

.7 ship's security alarm system required by Part IV "Radio Equipment", as well as AIS installation and long-range identification and tracking system equipment, as required by Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

Services listed under **9.3.7.2** to **9.3.7.**7 may not be supplied from the transitional source if they have their own accumulator batteries, by which they are supplied during the required period of timeacy.

9.3.8 For Class **INF2** and Class **INF3** ships, in accordance with the classification given in **7.3.2**, Part VI "Fire Protection", regardless of the navigation area and tonnage of the ships, the emergency source of electrical power shall supply the services listed in **7.3.6** and **7.3.8**, Part VI "Fire Protection" for a period of 36 h and **9.3.1** of this Part.

9.4 DISTRIBUTION OF ELECTRICAL POWER FROM EMERGENCY SOURCES

9.4.1 Under normal service conditions, emergency distribution board shall be supplied from the main distribution board. The supply feeder shall have an overload and short-circuit protection fitted at the main distribution board.

At the emergency distribution board, a switch shall be provided, which shall switch off automatically in the case of de-energizing the busbars of the main distribution board.

Where the main distribution board shall be supplied from the emergency distribution board, the automatic switch at the emergency distribution board shall be provided with short-circuit protection at least.

9.4.2 The emergency generator, during the stay of the ship in port, may be used to supply nonemergency consumers (refer also to 2.2.6, Part IX "Machinery").

In doing so, the following conditions shall be met:

provision is made for automatic disconnection of non-emergency consumers from the emergency distribution board to prevent overloading of the generator and to ensure the supply of emergency consumers;

damage of any control, protection and alarm circuits intended to maintain operation of the emergency generator during the stay of the ship in port, shall not affect the work of the main and emergency electrical power sources;

arrangements are provided to select the operating modes of emergency generators with a quick changeover to emergency mode being possible;

provision is made for instructions to be available onboard, for bringing all the controls (valves, switches, etc) in a position ensuring independent operation of the emergency generator when the ship is underway, and also containing information on the required oil fuel capacity, on the position of the operating mode switch (if any), on the position of ventilation closures, etc.

9.4.3 Consumers listed under **9.3.1** and **19.1.2** shall be supplied through separate feeders from the busbars of the emergency distribution board fitted up with relevant switch gear and protection. Supply of consumers mentioned under **9.3.1.2** to **9.3.1.6** and **19.1.2.1.2** to **19.1.2.1.6** may be effected from the main control console in the wheelhouse, which is supplied in conformity with 4.5.2.

9.4.4 Where a transitional source of power is available, consumers listed under **9.3.7** and **19.1.2.7** shall be supplied through a special distribution board on the feeders, of which no switches shall be fitted.

9.5 STARTING ARRANGEMENTS FOR EMERGENCY DIESEL GENERATORS

9.5.1 The following arrangements may be used as starting arrangements for emergency diesel generators:

.1 electric starter with its own accumulator battery and charging device;

.2 compressed air system with its own independent air receiver;

.3 hydraulic starting system;

.4 manual starting arrangements: starting handle for manual cranking, inertia starters, manually charged hydraulic accumulators or powder charge cartridges.

9.5.2 Each emergency generating set arranged to be automatically started shall be equipped with a starting device of an approved type with a stored energy capability of at least three consecutive starts.

The source of stored energy shall be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided.

In addition, a second source of energy shall be provided for additional three starts within 30 minutes unless manual starting can be demonstrated to be effective.

9.5.3 Where automatic starting of the emergency diesel generator is not required, manual starting is permissible with the use of one of the starting arrangements specified in **9.5.1.4**.

When manual starting is not practicable, the starting arrangements shall comply with the requirements of **9.5.2**.

9.5.4 The starting arrangements of the accumulator batteries and the electric drives of the machinery ensuring the functioning of the compressed air or hydraulic systems of the emergency diesel generator starting shall be supplied from the emergency switchboard by separate feeders.

9.6 ALARM SYSTEM AND PROTECTION OF EMERGENCY DIESEL GENERATOR DRIVES

9.6.1 Emergency diesel generator drives having power of 220 kW and above shall be equipped with a protective device ensuring the shutdown of the engine in case of overspeed.

9.6.2 All protective devices that may influence the shutdown of emergency diesel generator drives, except for those preventing overspeed, shall be automatically overridden when the emergency diesel generator is in remote control or automatic mode during navigation.

This requirement covers all emergency diesel generators regardless of their drives' output.

9.6.3 In addition to the remote fuel stop control, a local means of emergency shutdown of emergency diesel generator drives shall be provided.

9.6.4 For emergency diesel generator drives alarm system shall be activated at:

.1fuel oil leakage from high pressure pipes;

.2 lubricating oil pressure below the minimum permissible value;

.3 high temperature of cooling water or cooling air.

9.6.5 For drives having power of 220 kW and above, in addition, provision shall be made for alarm system activating at:

.1high lubricating oil temperature;

.2pressure or flow of cooling water below the minimum permissible value;

.3 overspeed.

9.6.6 For drives having power of more than 2250 kW or with cylinder bore of more than 300 mm, in addition, provision shall be made for alarm system activating at excess of the oil mist concentration in crankcase.

9.6.7 Alarm system shall comply with the requirements given in **2.4.1**, Part XV "Automation".

9.6.8 Grouped alarms shall be arranged on the navigation bridge.

9.6.9 Proceeding from the power of drives, local indication of the parameters listed in **9.6.4 – 9.6.6** shall be provided (within the same space as the emergency diesel generator) independent of the alarm and safety systems.

9.7 UNINTERRUPTIBLE POWER SYSTEM (UPS)

.1 Uninterruptible power system (UPS), in addition to the requirements set forth below, shall comply with the requirements of IEC 62040 or the relevant ISO or EN standards and the applicable requirements of other international and national standards recognized by the Register.

9.7.2 UPS complying with these requirements may be used as emergency or transitional sources of electrical power as required by this Part.

9.7.3 UPS type selection shall be appropriate to power supply requirements of the connected load equipment.

9.7.4 UPS shall be provided with a bypass, which ensures power supply to connected load from the ship's mains if the inverter fails.

9.7.5 Each UPS shall be provided with audible and visual alarm to be given for: .1 power supply failure to the connected load;

.2 earth fault;

.3 operation of battery protective device;

.4 when the battery is being discharged; and

.5 when the bypass is in operation for on-line UPS.

9.7.6 The requirements for location of the UPS shall be similar to the requirements for the location of the emergency or transitional source of electrical power.

9.7.7 UPS utilising sealed batteries may be located in any space other than the accommodation space, provided sufficient ventilation is ensured in the space.

9.7.8 UPS shall maintain rated voltage and frequency on the load side throughout the whole time necessary to supply the connected services.

9.7.9 On voltage recovery in the power supply circuit, the capacity of the UPS rectifier shall be sufficient to maintain rated voltage and frequency on the load side with simultaneous recharging the battery by the maximum possible charging current.

9.7.10 The accelerated (boost) charging of the UPS batteries by the maximum possible charging current shall be interlocked with the ventilation of the space where the UPS batteries are installed.

10. ELECTRICAL MACHINES

10.1 GENERAL

10.1.1 The materials of propulsion motors shafts, generators and slip coupling built into the shafting shall comply with the requirements of **3.7**, Part XIII "Materials".

10.1.2 Alternating-current generators together with voltage correctors shall be capable to sustain, under steady short-circuit conditions, at least three-times the rated current within 2 s.

10.1.3 Electric propulsion generators and electric propulsion motors, or, where justified, also machines of different designation, shall have heating arrangements to maintain their temperature at least 3°C above the ambient air temperature.

10.1.4 Generators built into the shafting of the main machinery shall have split stators and bearing shields if, due to the shaft arrangement, the stator displacement in the direction of the shaft from the rotor is not possible.

Such generators shall have an air gap preventing mechanical contact of the rotor and stator under the most unfavourable service conditions.

10.1.5 Rotors and armatures of alternating and direct-current machines shall be capable of withstanding for 2 min, without damage and permanent set, the following increased speeds of rotation:

.1 generators, rotating coverters and electric slip coupling and brakes: 120 % of the rated speed, but at least by 3 % more than the maximum speed transient process;

.2 series-wound motors: 120 % of the maximum permissible speed as indicated on the rating plate, but not less than 150 % of the rated speed;

.3 all motors other than mentioned above, 120 % of the maximum no-load speed.

10.1.6 Where a machine is so designed that after installation on board the ship its bottom portion is positioned below floor level, ventilation air intake shall not be through the bottom part of the machine.

10.1.7 Application of external cooling fans is not recommended for machines intended for installation on weather decks.

10.1.8 The power of electric motors supplied from an electrical power source, which does not comply with the requirements of **2.2.1.3**, shall be calculated taking into account the additional heating due to the higher harmonic components.

10.2 SLIP RINGS, COMMUTATORS AND BRUSHES

10.2.1 Direct-current machines for driving the propulsion plants and direct-current machines rated at 200 kW and over shall be provided with sight holes to enable observation of the commutator and brushes without removing the lids.

10.2.2 The permissible wear of commutator segments or slip rings shall be indicated on their sides. It shall be taken equal to at least 20 % of the commutator segment or slip ring height.

10.2.3 For armatures more than 1000 kg in mass provision shall be made to allow reconditioning of the commutator without removing the armature from the machine.

10.2.4 A flexible copper conductor shall be used for drawing current from brushes. Brush holder springs shall not be used for this purpose.

10.2.5 The position of brushes in direct-current machines shall be clearly and indelibly marked.

10.2.6 Commutator type machines shall be capable of operating practically without sparking at any load from zero to rated value.

No sparking shall be possible at the specified overloads, reversals or startups, to such an extent as to cause damage to brushes or commutators.

10.3 BEARINGS

10.3.1 Bearings shall be so designed as to avoid the possibility of oil splashing or leaking along the shaft and coming into contact with the machine windings or live parts.

10.3.2 The casing of the sliding bearing shall be fitted with a hole for excessive lubricating oil drain and with a lid in the upper part of the casing.

Oil level indicators shall be provided on machines rated at 100 kW or more.

10.3.3 Pressure lubrication system shall incorporate pressure indicators for oil entering the bearing.

10.3.4 In electric propulsion machinery, or machines of different designation, where so justified, provisions shall be made to prevent flow of shaft currents through sliding friction bearings.

10.3.5 Generators driven by belts or chains from the main machinery of the ship shall be so designed that the effect of the lateral forces is taken into account.

10.4 TEMPERATURE DETECTORS

10.4.1 Stators of alternating-current machines rated at over 5000 kW, or having a core length of more than 1 m, shall be provided with temperature detectors installed where the machine may be expected to develop the highest temperatures.

10.4.2 Embedded temperature detectors are recommended for electric motors with short-time or intermittent operating conditions.

10.4.3 It is recommended that overload protection for windlass-driving electric motors shall be by means of embedded temperature detectors so selected that the protection device will disconnect the motor when the temperature rise limit for the insulation employed is exceeded by more than 30 %.

The terminals of the detector shall be located so as to be easily accessible.

10.5 OVERCURRENT

10.5.1 Generators shall be so designed that after reaching the steady-state temperature corresponding to the rated load they shall be capable of sustaining overcurrent as specified in Table 10.5.1.

Table 10.5.1

Type of generator	Overcurrent, %	Duration of overload, s
a.c.	50	120
d.c.	50	15

10.5.2 Electric motors shall be so designed that they are capable of developing, without stopping or sudden rotation frequency changes, the increased torque specified in Table 10.5.2.

Table 10.5.2

№	Type of motor	Overload in torque, %	Duration of overload, s	Testing conditions
1	Synchronous motors, as well as squirrel-cage motors with starting current not less than 4,5 times the rated current	50	15	Frequency, voltage and excitation to be maintained at rated levels
2	Induction motors for continuous and intermittent duties	60	15	Frequency and voltage to be maintained at rated levels
3	Motors as specified in item 2, but for short-time and continuous duty with varying load	100	15	Ditto
4	Direct-current motors	50	15	Voltage to be maintained at rated level

10.5.3 For electric propulsion motors overload in torque and duration of overload, specified in **10.5.2**, are defined by the ship's designer taking into account changes in the main electric propulsion plant loads during maneuvering, sea passage, including navigation in difficult weather conditions etc.

10.6 ALTERNATING-CURRENT GENERATORS

10.6.1 General.

10.6.1.1 Each alternating-current generator shall have a separate, independent automatic voltage regulation system.

10.6.1.2 Alternating current generators shall possess sufficient excitation capacity to maintain the rated voltage with an accuracy of 10 % for 2 min at generator overcurrent equal to 150 % of the rated value and at a power factor 0,6.

10.6.1.3 Protection of alternating-current generators shall comply with the requirements of **8.2**.

10.6.2 Voltage regulation systems.

10.6.2.1 Alternating-current generators shall have automatic voltage regulation systems ensuring that the voltage may be maintained within (2,5 % of the rated value (up to 3,5 % for emergency generators) at all load changes from no-load to rated load values at the rated power factor. The speed in this case shall be within the range specified in **2.11.3**, Part IX "Machinery".

10.6.2.2 A sudden change in the balanced load of a generator running at rated speed and rated voltage, under given current and power-factor conditions, shall not cause a drop of voltage below 85 % or a rise above 120 % of the rated value. After the completion of transient processes, the generator voltage shall be restored within not more than 1,5 s with a deviation from the rated value being ±3%. For emergency sets these values may be increased, respectively, to 5 s and ±4% of the rated voltage.

Where no precise data are available on peak values of sudden load that may be connected additionally to the existing generator load, these may be taken equal to a load of 60 % of the rated current at a power factor of 0,4 or less, which is connected at idle speed and then disconnected. The speed in this case shall be within the range specified in **2.11.3**, Part IX "Machinery".

10.6.2.3 For alternating-current generators the deviation from sine voltage shall not be more than 5 % of the harmonic component peak value.

10.7 DIRECT-CURRENT GENERATORS

10.7.1 General.

10.7.1.1 Compound-wound and shunt-wound direct-current generators shall be equipped with automatic voltage regulation systems.

10.7.1.2 Protection of direct-current generators shall comply with the requirements ofм **8.2**.

10.7.2 Voltage regulations.

10.7.2.1 Voltage regulators of direct-current compound-wound generators shall enable reduction of no-load voltage, with the generator cold, by not less than 10 % below the rated generator voltage, taking into account the increased revolutions of the prime mover running at no load.

10.7.2.2 Manual voltage regulators shall be so designed that the voltage increases when their controls are rotated clockwise.

10.7.2.3 Voltage regulators of direct-current shunt-wound generators shall be so designed that, when the field current is removed, the field winding shall be closed to the discharge circuit.

10.7.2.4 Direct-current compound-wound generators shall have independent devices for voltage regulation within a tolerance of ±1% for generators rated at up to 100 kW, or within ±0,5% for generators of rating exceeding 100 kW.

The above regulation limits shall be maintained with the generator cold and hot and at any load within the operating load range of generators.

10.7.2.5 Direct-current sets comprising compound-wound generators shall have such external characteristics that the voltage of a hot generator adjusted to the rated value with an accuracy of ±1% at 20 % of the load does not vary at full load by more than ±1,5% for generators rated at 50 kW or over, and by more than ±2,5% for generators of lower output. Voltage variations in a compound-wound gene-rator running at 20 to 100 % of the rated load shall not exceed the following limits:

.1 ±3% for generators rated at 50 kW and more;

.2 ±4% for generators rated over 15 kW but less than 50 kW;

.3 ±5% for generators rated at 15 kW and less.

10.7.2.6 Direct-current sets comprising shunt-wound generators shall have such external generator characteristics and automatic voltage regulators that voltage is maintained to within ±2,5% of the rated value at all load variations from zero to the rated load.

10.8 ELECTROMAGNETIC BRAKES

10.8.1 The brake shall operate when the brake operating coil becomes de-energized.

10.8.2 A 30 % voltage drop below the rated value shall not cause a hot brake to operate.

10.8.3 Electromagnetic brakes shall allow of manual release.

10.8.4 Electromagnetic brakes shall be fitted with at least two pressure springs.

10.8.5 The shunt windings of a compound-wound electromagnetic brake shall be capable of holding off the brake even when no current flows through the series winding.

10.8.6 The shunt windings of electromagnetic brakes shall be so constructed or protected that they can be safe from damage at overvoltages such as occur when they are being disconnected (refer also to **5.4.3**).

10.9 ASYNCHRONOUS ELECTRIC MOTORS SUPPLIED FROM FREQUENCY CONVERTERS

10.9.1 Asynchronous electric motors supplied from frequency converters shall have output reserve in order to prevent overheat caused by the voltage curve harmonic distortion.

10.9.2 Stator winding of asynchronous electric motors less than 100 kW supplied from frequency converters shall be two-layer winding or single layer with equal length of conductors with F- or H-class reinforced insulation.

10.9.3 In order to reduce overvoltage in stator winding of asynchronous motors supplied from frequency converters with the pulse-width modulation (PWM) it is necessary to:

.1 apply star phase splicing of stator winding;

.2 optimum selection of impedance of the electric motor stator winding and cable between electric motor and frequency convertor;

.3 use control algorithm for frequency convertor limiting minimum pulse duration and pause between impulses.

11. TRANSFORMERS

11.1 GENERAL

11.1.1 The requirements of the Section apply to transformers listed in **3.3**.

For additional requirements for transformers with voltages over 1000 V, refer to **18.4**.

11.1.2 Dry-type transformers shall be used in ships. 11.1.3 Transformers shall have electrically separated windings for primary and secondary voltages.

11.2 OVERLOAD, VOLTAGE VARIATION AND OPERATION IN PARALLEL

11.2.1 Transformers shall be so designed as to be capable of withstanding 10 % overload for 1 h and 50 % overload for 5 min.

11.2.2 For single-phase and three-phase transformers used to supply the ship's mains, voltage variation at an active load between zero and rated load shall not exceed 5 % for transformers rated at up to 6,3 kVA per phase and 2,5 % for transformers of higher rating.

11.2.3 Transformers intended to operate in parallel shall have their winding connections grouped together, their transformation ratios shall be the same, and their short circuit voltages shall be such that the load on any transformer does not depart from the corresponding proportional part of power output of each transformer by more than 10 % of the rated current for a given transformer.

11.2.4 Nominal capacities of transformers for parallel work shall not differ from each other more than twice.

12. POWER SEMICONDUCTOR UNITS

12.1 GENERAL

12.1.1 In power semiconductor units use shall be made of semiconductor elements of silicone type.

12.1.2 To prevent condensation in semiconductor units having the dissipation power above 500 W, provision shall be made for heating so that their temperature is at least by 3°C higher than that of the ambient air.

12.1.3 Power semiconductor units shall be provided with air cooling (natural or artificial).

12.1.4 For power semiconductor units with forced cooling, provision shall be made for the protection reducing or disconnecting the load in case of inadequate cooling.

The activation of protection shall be preceded by the activation of light and sound alarms for exceeding the maximum permissible temperature of cooling medium at the system outlet.

12.2 PERMISSIBLE PARAMETERS OF VOLTAGE DISTORTION

12.2.1 The total harmonic distortion in the ship mains depending upon the operation of the power semiconductor units shall not exceed the values specified in **2.2.1.3**.

12.2.2 The factor of maximum relative deviation of instantaneous voltage value from the first harmonic component shall not exceed 30 %.

Factor K_{MD} shall be determined by the formula:

$$K_{MD} = \frac{U_m - U_{1m}}{U_{1m}} 100\ \%, \qquad (12.2.2)$$

where U_m – peak value of the ship mains voltage;

U_{1m} – peak value of the first harmonic component.

12.3 CONTROL AND SIGNALLING SYSTEMS

12.3.1 Semiconductor arrangements shall be provided with light signals for connection or disconnection of power circuits and control circuits.

12.3.2 The power section of semiconductor arrangements shall be electrically insulated from the control system.

12.3.3 The long-term current deviation in the parallel branches of semiconductor arrangements shall not exceed 10 % of average current value.

12.3.4 The operation of semiconductor arrangements shall not be hampered by the failure of particular gates. Where the load upon particular gates exceeds permissible values, it shall be reduced automatically.

When a gate fails, light and sound signals shall be activated.

12.4 MEASURING INSTRUMENTS

12.4.1 Semiconductor arrangements shall be fitted up with measuring instruments in accordance with their purpose.

12.4.2 In the scales of measuring instruments of semiconductor arrangements, maximum permissible parameter values shall be marked off. Where forced cooling is applied, the maximum permissible temperature shall be marked off clearly in the scale of the instrument for measuring the cooling air temperature.

13. ACCUMULATOR BATTERIES

13.1 GENERAL

13.1.1 Accumulator batteries shall be so constructed that the loss of capacity of a fully charged battery due to self-discharge after 28 days out of operation at a temperature of (25 ± 5)°C does not exceed 30 % of rated capacity for acid batteries and 25 % for alkaline batteries.

13.1.2 Battery containers and closures for holes shall be so constructed and secured as to prevent spilling or splashing of the electrolyte when the container is inclined on any side to an angle of 40° from the vertical. Closures shall be made from durable material resistant to electrolyte.

Closure design shall be such as to avoid building up of excess gas pressure inside the battery.

13.1.3 The mastics used shall not change their properties or deteriorate at ambient temperature changes within –30 до +60°C.

13.1.4 Materials used for fabrication of crates to house battery cells shall be resistant to electrolyte.

Individual cells arranged within the crates shall be so secured that it is impossible for them to move relative to one another.

13.1.5 Where batteries are fitted for use for essential and emergency services a schedule of such batteries shall be compiled and maintained.

The schedule, which shall be reviewed by the Register, shall include the following information regarding the battery:

type and manufacturer;

voltage and capacity;

location;

equipment and systems served;

maintenance/replacement cycle dates;

date of last maintenance or replacement;

for replacement batteries in storage, the date of permissible shelf life.

Details of the schedule shall be included in the ship's safety management system specified in Chapter IX of SOLAS 74.

13.1.6 Where batteries are replaced, they shall be of an equivalent performance type, which shall be reflected in appropriate instructions.

13.1.7 Where vented type battery replace valve-regulated sealed type at its location, the requirements of the Rules relevant to the location and ventilation of the batteries shall be met.

13.2 ARRANGEMENT OF ACCUMULATOR BATTERIES

13.2.1 Batteries having a voltage in excess of the safety voltage, as well as batteries having a capacity over 2 kW computed from the maximum charging current and the rated voltage, shall be located in special battery compartments accessible from the deck, or in appropriate boxes installed on deck.

These spaces shall be special electrical spaces. Batteries having a charge capacity of 0,2 kW up to 2 kW may be installed in boxes or cabinets located inside the ship's hull.

In ships with low-power electrical installation, except passenger ships, the above batteries may be installed in the machinery space in such a way that their upper section is at least above the margin line in case the ship is flooded.

Accumulator batteries intended for the electric starting of internal combustion engines except for emergency units may be installed in machinery spaces in special cabinets with sufficient ventilation.

Batteries having a charge capacity less than 0,2 kW and unattended batteries giving off no gases in operation are allowed to be installed in any space, other than accommodation spaces, provided they are protected from the action of water and mechanical damage and do not harmfully affect the surrounding equipment.

13.2.2 The acid and alkaline batteries shall not be placed in one compartment or in one box.

The vessels and instruments intended for the batteries with different electrolytes shall be placed separately.

13.2.3 The inside part of a battery compartment or cabinet, as well as all structural parts, which may be subjected to harmful effects of electrolyte or gas, shall be suitably protected.

13.2.4 Accumulator batteries and individual cells shall be properly fixed in position. In case they are installed on shelves in two or more rows, all the shelves shall have a clearance of at least 50 mm on the face and back side for air circulation, and the distance from the deck to the plugs in the upper row of cells shall not exceed 1500 mm.

13.2.5 When installing the accumulator batteries or individual accumulators (cells), provision shall be made for fitting linings and spacers between them that will ensure a clearance for circulation of air of not less than 15 mm on all sides.

13.2.6 Warning notices indicating the danger of explosion shall be provided on the doors leading to the battery compartment or nearby, as well as on the boxes containing the accumulators.

13.3 HEATING

13.3.1 The battery compartments and boxes wherein temperature in operation may fall down below +5°C, shall be heated.

The heating is allowed to be effected by the heat produced in adjacent spaces, by water or steam generators installed inside the battery rooms, as well as by safe type electrical heating appliances with protection level in accordance with **2.9.3.3**.

13.3.2 The heating system valves shall be located outside the battery compartments.

13.3.3 The shipboard air conditioning system shall not be used for heating the battery compartments.

13.4 VENTILATION

13.4.1 The battery compartments and boxes, except for unattended batteries not releasing gases during operation, shall have sufficient ventilation that will prevent accumulation of explosive air-gas mixture.

The ventilation system shall meet the requirements of **12.10**, Part VIII "Systems and Piping".

13.4.2 The battery compartments equipped with mechanical ventilation shall be provided with devices that will prevent charging of accumulator batteries before ventilation has been switched on.

Charging cycle shall be automatically discontinued, shall the ventilators stop.

13.5 CHARGING OF ACCUMULATOR BATTERIES

13.5.1 Provision shall be made for charging facilities to charge the accumulator batteries of essential services within 8 h.

In case an additional battery is used substituting that being charged, the charging time may exceed 8 h.

13.5.2 The charging facilities shall have means for measuring the voltage across battery terminals and charging current, as well as discharging current for emergency sources of electrical power.

13.5.3 In ships equipped with portable accumulator-fed lanterns or with spare accumulator-fed navigation lanterns the facilities shall be provided for charging the accumulators of these lanterns.

13.6 INSTALLATION OF ELECTRICAL EQUIPMENT IN BATTERY COMPARTMENTS

13.6.1 Apart from safe type lighting fixtures and heating appliances, as well as cables led to accumulators, lighting fixtures and heating appliances, no other electrical equipment shall be installed in battery compartments.

Cables led to accumulator batteries lighting fixtures and heating appliances may run openly, provided they have metal armour or braid covered with non-metal sheath and this metal armour or braid is reliably earthed at both ends.

13.7 ELECTRICAL STARTERS FOR INTERNAL COMBUSTION ENGINES

13.7.1 Number of starter accumulator batteries.

13.7.1.1 In a ship equipped with electrically-started internal combustion engines, irrespective of the number of such engines, not less than two starter batteries shall be permanently installed for starting each of the main and auxiliary engines, or not less than two common batteries for starting all the engines.

Moreover, provision shall be made for a permanent switching system that will ensure possible use of any battery for starting any of the engines in the group serviced by this battery. In this case parallel connection of the batteries is not allowed.

13.7.1.2 For ships of restricted area of navigation **R3, R3-IN** and **D-R3-S**, **D-R3-RS** and also for ships of restricted area of navigation **R2** with the electrical installation of low power (other than passenger ships), it is permitted to have only one starter accumulator battery, provided that it may be used for starting all the engines.

13.7.2 Battery characteristics.

13.7.2.1 Each starter battery shall be designed to withstand the discharging current in starter duty that will correspond to the maximum current through the most powerful starting electric motor.

13.7.2.2 Capacity of each battery shall be sufficient for six starts of the engine in the ready-forstart condition, or in case of two or more engines, for not less than three starts of each engine.

Total capacity of the batteries for starting main engines shall provide the required number of starts during 30 min.

13.7.2.3 In computing battery capacity, the duration of each start shall be considered not less than 5 s.

13.7.3 Charging facilities.

13.7.3.1 A starter battery charging facility shall be supplied by a separate feeder from the main switchboard even if the battery is charged from the appurtenant generator.

13.7.3.2 For ships of restricted area of navigation **R3, R3-IN** and **D-R3-S**, **D-R3-RS** and also for ships of restricted area of navigation **R2** with the electrical installation of low power (other than passenger ships) the starter battery may be charged only from the appurtenant generator.

14. ELECTRICAL APPARATUS AND ACCESSORIES

14.1 ELECTRICAL APPARATUS

14.1.1 General.

14.1.1.1 The design of switchgear with renewable contacts shall be such that renewal of contacts shall be possible by means of standard tools, without dismantling the switchgear or its basic components.

14.1.1.2 All switches, circuit breakers and isolating switches, except those for cabins, shall be provided with mechanical or electrical contact-making position indicators located where the apparatus is actuated by the operator.

14.1.1.3 The positions of controller and master controller drums shall be rigidly locked by mechanical means, location in zero position being more rigid than elsewhere. Controller and master controlled drums shall be fitted with a scale and an indicator of position.

14.1.1.4 Machine control gear, except such as is used for smooth regulation, shall be so constructed that the end and intermediate fixed positions are easy to feel at various control stages while movement beyond the end positions shall be impossible.

14.1.2 Manually operated controls.

14.1.2.1 The direction of movement of manually operated controls of switchgear or machine control gear shall be such that clockwise rotation of a handle (lever) corresponds to closing of an apparatus, start-up of a motor, increased speed, increased voltage, and so forth.

Where lifting or lowering mechanisms are under control, clockwise rotation of a handle (handwheel) or shifting of a handle (lever) toward the operator shall correspond to lifting movement, and counterclockwise rotation or shifting away from the operator to lowering movement.

14.1.2.2 Switchgear push buttons shall be so designed that they cannot be actuated accidentally.

14.1.3 Motor-operated gear.

14.1.3.1 Actuators of switches and circuit breakers shall be so designed that in the event of loss of supply to the actuating motor the switch or circuit breaker contacts remain in closed or in open position only.

14.1.3.2 Electric motor actuators shall provide for reliable closing of the apparatus at all changes of the control voltage within 85 to 110 % of the rated value and in case of alternating current at frequency deviation (frequency range for an electrical power plant with variable frequency main power source) within ±5% of the rated frequency.

14.1.3.3 A drop of control voltage down to 70 % of the rated value shall not result in opening the apparatus contacts, or reducing the pressure thereof.

14.1.3.4 The design of a motor-actuated switchgear shall embody a provision for manual operation.

14.1.4 Coils.

14.1.4.1 A conductor or a shoe shall be attached to a coil winding so as to avoid the mechanical stresses of the connection affecting the coil turns.

The tapping of voltage coils shall be made from flexible stranded conductor, except where the contact terminals are secured directly to the coil frame.

14.1.4.2 The coils of electromagnetic apparatus shall bear notations giving particulars of their characteristics.

14.1.5 Resistor elements.

14.1.5.1 Resistor elements shall be easily replaceable, in sections or in total.

14.1.5.2 Resistors shall be so disposed and ventilated that they do not heat other devices beyond the permissible limits.

14.1.5.3 The joints between resistor elements or between these and terminals shall be effected by welding or by mechanical press-fitting where there is no need to provide for their dismantling.

Soldering is admissible where there is no risk of temperature rise at the point of junction above the limits specified for the solder.

14.1.6 Fuses.

14.1.6.1 Fuse link housing shall be of totally enclosed type and allow no arc ejection to the outside, or sparking, or any other harmful effect upon the adjacent parts in case the fuse blows.

14.2 ELECTRICAL ACCESSORIES

14.2.1 General.

14.2.1.1 The enclosures of accessories and fittings shall be constructed from materials of adequate mechanical strength, which are corrosion-resistant or adequately protected from corrosion and at least flame-retardant.

The enclosures of accessories and fittings designed for installation on weather decks, in refrigerated cargo spaces, fish processing shops, or other humid areas shall be made of brass, bronze, or equivalent alloy, or from plastics of suitable quality.

If steel or aluminium alloys are used, anti-corrosive protection shall be provided. It is inadvisable to use threaded connections or tight-fit mating of parts in accessories and fittings made of aluminium alloys.

14.2.1.2 Insulating parts, to which current-carrying components are fixed, shall be made of materials that do not evolve gases as would ignite from an electric spark at a temperature up to and including 500°C.

14.2.1.3 The lighting fixtures designed to be mounted on or close to combustible materials shall be so constructed as not to get heated over 90°C.

14.2.2 Lampholders.

14.2.2.1 The design of lampholders fitted with screw caps shall be such as to effectively prevent the lamps from getting loose in service.

14.2.2.2 No switches are allowed to be fitted in lampholders.

14.2.2.3 Each lighting lampholder shall be marked to indicate rated voltage and allowable current or load.

14.2.3 Plug and socket connector.

14.2.3.1 The pin jacks of socket outlets shall be so constructed as to ensure permanent pressure in contact with the plug pins.

14.2.3.2 Plugs with slotted pins are not allowed for use. The pins of plugs designed for currents in excess of 10 A shall be cylindrically shaped, solid or hollow.

14.2.3.3 Socket outlets and plugs for voltages exceeding the safety level shall have contacts for connecting the earth continuity conductors of the incoming cables from current consumers.

14.2.3.4 Socket outlets having protective enclosures shall be so constructed that the required degree of protection is ensured regardless of whether the plug is in or out of the socket outlet.

14.2.3.5 Socket outlets rated at over 16 A shall be provided with built-in switches. Provision shall be also made for interlocking such socket outlets to prevent the possibility of the plug being inserted or withdrawn when the socket switch is in the "closed" position.

14.2.3.6 Where socket outlets are not interlocked, the clearance between contacts in air or across the insulation surface shall be such that no short circuit is possible due to arcing over when the plug is withdrawn while carrying a load 50 % above the rated current at rated voltage.

14.2.3.7 Socket outlets and plugs shall be so designed that it is not possible to insert only one live contact pin into the socket outlet, or insert a live contact pin into the earthing contact. Besides, the design of the outlets intended for connecting the motors (gears), the direction of rotation (operation) of which depends on the change of the sequence of phases or poles connected, shall exclude the possibility of the sequence change.

When the plug is inserted into the socket outlet, the earthing part of the plug shall make contact with the earthing part of the socket outlet before connecting the live pins.

14.2.3.8 In socket outlets, plugs and branched pin jacks, no fuses shall be fitted.

15. ELECTRICAL COOKING AND HEATING APPLIANCES

15.1 GENERAL

15.1.1 Only stationary-type electrical cooking and heating appliances are permitted for use.

15.1.2 Electrical cooking and heating appliances shall be supplied from the main switchboard or from distribution boards subject to the requirements of **6.2.1**.

15.1.3 The supporting structural parts of electrical cooking and heating appliances, as well as the internal surfaces of enclosures, shall be fabricated entirely from non-combustible materials.

15.1.4 In heated condition, permissible loss current shall not exceed 1 mA per 1 kW of rated power for a separately connected heating element or 10 mA for the appliance as a whole.

15.1.5 Electric cooking and heating appliances shall be so designed that the temperature of their components, which shall be handled by the personnel or which can be touched inadvertently, does not exceed the value indicated in Table 15.1.5.

Table 15.1.5

№	Item	Permissible temperatures, °C
1	Control handles and other parts to be handled during long periods of time	
	Metallic	55
	Non-metallic	65
2	Same, but where short-time contact is possible:	
	Metallic	60
	Non-metallic	70
3	Enclosures of electric space heating and cooking appliances at ambient temperature of 20°C	80
4	Air coming out from electric space heating appliances into heated spaces	110

15.2 HEATING APPLIANCES

15.2.1 Electric heating appliances intended for space heating shall be of stationary type. These appliances shall be provided with devices for disconnection of the supply source when the temperature rise of the enclosure exceeds the permissible limit.

15.2.2 If built-in disconnecting devices are not provided in the heating and cooking appliances, such devices shall be installed in the rooms wherein these appliances are located. Switches shall disconnect power supply at all poles or phases.

15.2.3 The enclosures of electric heating appliances shall be so constructed as to prevent the possibility of any objects being placed upon them.

15.2.4 Stationary heating appliances rated at 380 V and upwards and admitted for use in accordance with Table 4.2.3 shall be protected against access to live parts, except with the aid of special tools. The enclosures shall bear notices giving the voltage value.

15.2.5 Electric cooking appliances forming part of galley equipment shall be so constructed as to avoid the possibility of cooking utensils being brought into contact with live parts, and to prevent short circuits or damage to insulation due to liquid spilling or leakage.

15.2.6 Sauna shall be fitted with the temperature limiter, which shall cut off the electrical heater from the mains (at that, electrical heater control circuits shall also be de-energized), if the temperature in the area of 0,3 m from the ceiling exceeds 140°C. In this area the electrical heater control devices (thermostats and temperature limiters) and associated cables withstanding a temperature not less than 170°C may only be installed.

Electrical sauna heaters shall comply with the requirements of **2.1.5.1**, Part VI "Fire Protection".

15.3 OIL, FUEL AND WATER HEATERS

15.3.1 In addition to the requirements of the Chapter, heaters shall meet the requirements of Section 6, Part X "Boilers, Heat Exchangers and Pressure Vessels".

15.3.2 Oil and fuel having a flash point above 60 °C may be heated by means of electric heaters, provided the requirements of 15.3.3 and 15.3.4 are fulfilled.

15.3.3 Electric heaters for pipelines shall be equipped with devices for temperature control, light signals for indication of operating conditions and also with light and sound signals for indication of fault conditions and inadmissible temperature rise.

15.3.4 Electric heaters for oil and fuel heating in tanks shall be equipped with devices for temperature control of the heated medium, temperature sensors for surfaces of heating coils, low level indicators and means for disconnection of power supply to the heaters in case the upper temperature limit or the lowest permissible level is exceeded.

15.3.5 Oil and fuel heaters shall be fitted up with devices for temperature control of the medium heated.

Irrespective of those devices, a manually disengaged device shall be provided for deenergizing the heaters as soon as their surface temperature reaches the value at least 15°C lower than the flash point.

For self-regulating heaters protection may be omitted.

15.4 SYSTEMS UTILISING HEATING CABLES

15.4.1 Systems utilising heating cables for removing ice and avoiding icing shall be provided for ship's arrangements, equipment and spaces intended for:

performing by the ship its purpose (descriptive notation in the class notation);

maintaining manoeuvrability;

maintaining stability;

safety of crew (rafts, boats, ladders, guard rails, etc.).

15.4.2 Heating capacity of such systems shall not be less than:

300 W/m^2 for the spaces of open decks, helidecks, ladders and gangways;

200 W/m^2 for superstructures;

50 W/m^2 for guard rails with internal heating.

15.4.3 In the systems utilising electrical heating cables, particular attention shall be paid upon the heat transfer between the cable and the equipment (space) to be heated to provide efficient heating.

15.4.4 The switchboard for the said systems shall be equipped with:

wattmeter or amperemeter to indicate the total load;

name plate indicating the rated load of each circuit and the switchboard as a whole;

residual-current device for each circuit;

load signal lamps for each circuit.

15.4.5 The heating cables shall be protected against overload exceeding 125 % of the rated current of the circuit. For cables of self-regulating type the overload protection may be omitted.

15.4.6 The use of heating cables for heating of pipelines carrying combustible media, as well as for pipelines and valves located in dangerous rooms and spaces, is only allowed when fitted with the appropriate type of explosion protection proved by a competent body certificate.

16. CABLES AND WIRES

16.1 GENERAL

16.1.1 The requirements of this Section do not apply to radio frequency, telephone cables, and to power cables designed for voltages above 1000 V.

16.2 CABLE CONDUCTORS

16.2.1 1 Cables intended for supplying essential services shall have stranded conductors (refer also to **16.8.1.2**).

Table 16.2.1 specifies the minimum number of wires per conductor.

16.2.2 Connections of separate wires of the conductor shall be displaced from one another by not less than 500 mm along the length of the conductor.

Such connections shall not impair the mechanical and electrical properties of the wire nor change the cross-sectional area of wires or the conductor as a whole.

Table 16.2.1

Nominal cross-sectional area of conductor, mm^2	Minimum number of wires per conductor	
	circular non-tightened conductors	tightened sector and circular conductors
0,5–6	7	–
10–16	7	6
25–35	19	6
50–70	19	15
95	37	15
120–185	37	30
240–300	61	30

Note. The ratio between nominal diameters of any two wires in the mechanically tightened cable conductor shall not exceed 1:1,3, and for conductors formed geometrically, but not tightened, 1:1,8.

16.2.3 Separate wires of rubber-insulated copper conductors shall be tinned or coated with suitable alloys.

Tinning or other anticorrosive coating of external stranding or of all wires of a rubber-insulated core may be dispensed with, if the manufacturer takes steps to guarantee that the rubber insulation does not affect adversely the metal of the conductor.

No tinning is required for conductors provided with other types of insulation.

16.3 INSULATING MATERIALS

16.3.1 For conductors of cables and wires, insulating materials specified in Table 16.3.1 may be used.

Table 16.3.1

Type of insulating compound	Abbreviated designation	Maximum rated temperature during normal operation, °C[1]
1	2	3
Thermoplastic		
Polyvinyl chloride or copolymer of vinyl chloride and vinyl acetate	PVC	70
Elastomeric or thermoset		
Ethylene-propylene rubber or similar (EPM or EPDM)	EPR	90
Hard grade ethylene prorylene rubber	HEPR	90
Cross-linked polyethylene	XLPE	90
Silicon rubber	S 95	95

Table16.3.1continued

1	2	3
Ethylene-propylene rubber or similar (EPM or EPDM) halogen-free	HF EPR	90
Hard grade halogen-free ethylene propylene rubber	HF HEPR	90
Halogen-free cross-linked polyetylene	HF XLPE	90
Halogen-free silicon rubber	HF S 95	95
Halogen-free cross-linked polyolefin	HF 90	90
[1] Wire temperature for calculating the permissible continuous load of cable.		

16.4 CABLE SHEATHING

16.4.1 Protective sheathing of cables and wires may be manufactured of non-metallic materials as specified in Table 16.4.1, lead, copper.

Table 16.4.1

Type of non-metallic solid sheathing compound	Abbreviated designation	Temperature limit of the cable,°C
Thermoplastic		
Polyvinyl chloride or copolymer of vinylchloride and vinyl-acetate	ST 1 ST 2	60 85
Halogen-free	SHF 1	85
Elastomeric or thermoset		
Polychloroprene rubber	SE 1	85
Chlorsulphonated polyethylene or chlorinated polyethylene rubber	SH	85
Halogen-free	SHF	85

16.4.2 Sheathing shall be of uniform thickness within allowable limits, throughout the manufacturing length of cable, and shall envelope the cable cores concentrically.

The sheaths shall form an impervious covering in tight contact with the protected cores.

16.4.3 Lead cable sheaths shall be made of appropriate alloys specified by the national standards.

Pure lead sheaths may only be used when the lead sheath is covered with an additional protective envelope.

16.5 PROTECTIVE COVERINGS

16.5.1 Metal shielding braid shall be made of tinned copper wire or polymer-coated aluminium strip with drainage tinned copper wire. If plain copper wire is used, it shall be protected by suitable sheath.

Non-shielding braids may be made of galvanized steel wires.

The braid shall be uniform and its density shall be such that its mass is at least equal to 90 % of the mass of tube of equal diameter made of the same material and with a wall thickness equal to the braiding wire diameter.

16.5.2 Metal armour shall be made of annealed and galvanized steel wire or tape, wound helically, with a suitable pitch, over the cable sheath or an intermediate bedding over the sheath in such a way that a continuous cylindrical layer is formed to assure adequate protection and flexibility of the finished cable.

On special demand, the armour may be made of non-magnetic metals, using the techniques described above.

16.5.3 Cable armour or braid made of steel tape or wire shall be effectively protected against corrosion.

16.5.4 Armour bedding shall be made of moisture-resistant materials.

16.6 MARKING

16.6.1 Rubber- or polyvinylchloride-insulated cables having a limiting temperature at core 60°C shall be marked in such a manner as would enable their identification.

16.6.2 Cable cores shall be marked in such a manner as to assure adequate preservation of the markings. In multi-core cables with cores arranged in several concentric layers at least two adjacent cores in each layer shall be marked with different colours.

16.6.3 Cables of fire resistant type shall be clearly marked.

16.7 HOOKUP WIRES

16.7.1 For internal wiring of distribution boards and electric devices, single-wire insulated conductors may be used (refer also to Table 16.3.1).

16.7.2 Non-insulated wires and busbars are permitted for use only for internal wiring of electrical devices.

The external wiring with non-insulated wires or busbars is not allowed unless they are reliably guarded.

16.8 CABLING

16.8.1 General.

16.8.1.1 Use shall be made of flame-retarding or non-combustible cables and conductors with copper cores manufactured and tested in compliance with this Part of the Rules, national standards ДСТУ IEC 60092-350, ДСТУ IEC 60092-353, ДСТУ IEC 60092-360, ДСТУ IEC TR 60092-370, ДСТУ IEC 60092-376, as well as with the relevant requirements IEC and IEC 60092-352 and IEC 60092-354.

Cables manufactured and tested in compliance with the standards other than those specified above shall be accepted provided they are in compliance with international or national standards and are of an equivalent or higher safety level than those.

Use of flexible or optical fibre cables used for special purposes may be allowed provided they are manufactured and tested according to the approved standards. In this case, IEC 60331-23 for data transfer cables and IEC 60331-25 for optical fibre cables may be used.

As far as the fire resistance testing of cables is concerned, use shall be made of IEC 60331-1 for cables with outside diameter more than 20 mm and IEC 60331-21 or 60331-2 for other cables.

16.8.1.2 Cables and wires having stranded conductors shall be used, the cross-sectional area of the conductors being not less than:

.1 1,0 mm^2 for power, control and signalling circuits of essential services and for power circuits of other services;

.2 0,75 mm^2 for control and signalling circuits;

.3 0,5 mm^2 with the number of cores in the cable not less than four for instrumentation and internal communication circuits.

For power circuits supplying non-essential services, the use is permitted of cables with single-wire conductors having a cross-sectional area of 1,5 mm^2 and less.

In data transfer circuits high-frequency cables may be used with the core diameter of 0,4 – 0,8 mm considering mechanical strength of such cables in compliance with IEC 60092-370.

16.8.1.3 In circuits with heavy inductive and capacitive loads, the use shall be made of cables designed for working voltages approximately equal to twice the rated voltage of the circuit.

16.8.1.4 Maximum permissible temperature for the insulating material of the cable cores or wires shall be at least 10°C higher than the maximum specified ambient temperature.

16.8.1.5 In locations affected by the action of petroleum products or other aggressive medium, the use shall be made of cables having a sheath resistant to such medium. Cables not having such properties may be installed in such locations only fitted in metallic pipes (refer to **16.8.8**).

16.8.1.6 In locations where cables may be subjected to mechanical damage, the use shall be made of cables having an appropriate armour, while other types of cables in such locations shall be protected with special reliable covers or shall be installed in metallic pipes (refer to **16.8.8**).

16.8.1.7 Cables supplying the electric drives of the sprinkler system and of the fire pump from the emergency source of electrical power and running through casings of machinery spaces of category A, galleys, drying rooms and other similar fire-hazardous spaces, shall be of fire-resisting type or protected from the action of flame.

The above requirements cover the remote-control cables of those devices as well.

16.8.1.8 Cables for services required for operations under fire conditions, including cables for their power supply (refer to **16.8.1.11**) shall be routed clear of high fire risk spaces (refer to **16.8.1.9**), and in addition to passenger ships, main vertical fire zones, except for cases, when the services themselves are installed in such spaces. Where such installation of cables is necessary, the cables shall be of fire resistance type according to **16.8.1.1**.

16.8.1.9 The high fire risk spaces include:

machinery spaces of category A;

spaces containing fuel treatment equipment and other highly flammable substances;

galleys and pantries containing cooking appliances;

laundries containing drying equipment;

accommodation spaces of high fire risk;

paint rooms, store rooms and similar spaces for storage of flammable liquids;

enclosed and semi-enclosed spaces requiring installation of safe-type electrical equipment.

16.8.1.10 Cables, distribution gear, switch apparatus and protective devices associated with these services, specified in **16.8.1.11**, shall be so designed or installed that the likelihood of the device failing in case of fire in any one such space or area is minimised.

16.8.1.11 Among the services required for operation under fire conditions are the following:

general alarm;

fire extinguishing systems;

fire detection and alarm systems;

warning alarm of fire extinguishing system release;

controls of fire doors with door-position indicators;

control of watertight doors with door-position indicators and warning alarm;

emergency lighting;

public address system;

low-location lighting;

remote emergency shutdown arrangements for systems, which operation may support the propagation of fire and/or explosion.

16.8.1.12 Use of fire resistant cables for devices listed in **16.8.1.11** is not mandatory provided that:

.1 fail safe functioning of devices is provided by, at least, two-loop or radial laying of cables spaced apart as far as practical so that if one loop or radial section fails, the rest sustain operability of the devices;

.2 the devices are provided with self-monitoring with such damages like a short circuit, an open-circuit fault, earth fault, or trouble-free functioning of these devices is ensured by duplicating cables laid in separate runs spaced apart as far as practical.

16.8.2 Choice of cables and wires for loads required.

16.8.2.1 Permissible continuous loads on single-core cables and wires with different insulation materials shall comply with the values specified in Table.

16.8.2.1. The current ratings given in the Table are applicable to the following cases of cable installation:

when installing not more than 6 cables in one bunch or in one row closely adhering to one another;

when installing cables in two rows, regardless of the number of cables in one row, on condition that a free space for air circulation is provided between each group or bunch of 6 cables.

When installing more than six cables in one bunch, which may be under rated current simultaneously or when no free space for air circulation between them is provided, the permissible current ratings for the given cross-sectional area shall be reduced by 15 % (factor 0,85).

Table 16.8.2.1. **Current ratings in continuous service of single-core cables and wires with different insulation materials for ambient temperatures of 45°C**

Nominal cross-sectional area of conductor, mm²	**Insulating material**				
	Polyvinylchloride	**Heat-resistant polyvinylchloride**	**Butyl rubber**	**Ethylene-propylene rubber of cross-linked polyethylene**	**Silicone rubber or mineral insulation**
	Maximum permissible conductor operating temperature, °C				
	60	75	80	85	95
1	8	13	15	16	20
1,5	12	17	19	20	24
2,5	17	24	26	28	32
4	22	32	35	38	42
6	29	41	45	48	55
10	40	57	63	67	75
16	54	76	84	90	100
25	71	100	110	120	135
35	87	125	140	145	165
50	105	150	165	180	200

70	135	190	215	225	255
95	165	230	260	275	310
120	190	270	300	320	360
150	220	310	340	365	410
185	250	350	390	415	470
240	290	415	460	490	–
300	335	475	530	560	–

16.8.2.2 Current ratings in amperes for cross-sectional areas given in Table 16.8.2.1 and also for any other cross-sectional areas shall be calculated from the formula

$$I = \alpha\, S^{0,625} \qquad (16.8.2.2)$$

where α – = factor corresponding to the maximum permissible service temperature of the conductor obtained from Table 16.8.2.2;
S – nominal cross-sectional area of conductor, in mm².

16.8.2.3 The permissible current ratings for double-, triple- and quadruple-core cables shall be determined by reducing the values given in Table 16.8.2.1 for the given cross-sectional area with the use of correction factors:

Table 16.8.2.2

Maximum permissible conductor operating temperature, °C	**Factor α for nominal cross-sectional area *S*, mm²**	
	≥ 2,5	**< 2,5**
60	9,5	8
65	11	10
70	12	11,5
75	13,5	13
80	15	15
85	16	16
90	17	18
95	18	20

0,85 for double-core cables; 0,7 for triple- and quadruple-core cables.

16.8.2.4 The permissible current ratings for cables and wires in circuits of intermittent or shorttime service shall be determined by multiplying the current ratings for continuous service stated in Table 16.8.2.1 or chosen according to **16.8.2.2** by the correction factors given in Table16.8.2.4.

***Table 16.8.2.4.* Correction factors for cables and wires with or without metal sheathing**

Nominal crosssection of conductor, mm²	**Intermittent service, intermittence ratio, 40 %**		**Short-time service, 30 min**		**Short-time service, 60 min**	
	Cable and wire					
	with metal sheathing	without metal sheathing	with metal sheathing	without metal sheathing	with metal sheathing	without metal sheathing
1	2	3	4	5	6	7
1	1,24	1,09	1,06	1,06	1,06	1,06
1,5	1,26	1,09	1,06	1,06	1,06	1,06
2,5	1,27	1,10	1,06	1,06	1,06	1,06
4	1,30	1,14	1,06	1,06	1,06	1,06
6	1,33	1,17	1,06	1,06	1,06	1,06
10	1,36	1,21	1,08	1,06	1,06	1,06
16	1,40	1,26	1,09	1,06	1,06	1,06
25	1,42	1,30	1,12	1,06	1,06	1,06
35	1,44	1,33	1,14	1,07	1,07	1,06
50	1,46	1,37	1,17	1,08	1,08	1,06
70	1,47	1,40	1,21	1,09	1,09	1,06
95	1,49	1,42	1,25	1,12	1,11	1,07
120	1,50	1,44	1,28	1,14	1,12	1,07
150	1,51	1,45	1,32	1,17	1,14	1,08
185	–	–	1,36	1,20	1,16	1,09
240	–	–	1,41	1,24	1,18	1,10

300	–	–	1,46	1,28	1,20	1,12

16.8.2.5 The permissible current ratings given in Table 16.8.2.1 refer to the ambient temperature of 45°C.

The correction factors for converting the permissible current ratings to be introduced depending on the ambient temperature are stated in Table 16.8.2.5.

***Table 16.8.2.5.* Correction factors depending on ambient temperature**

Maximum permissible conductor operating temperature, °C	**Ambient temperature, °C**										
	35	40	45	50	55	60	65	70	75	80	85
60	1,29	1,15	1,00	0,82	–	–	–	–	–	–	–
65	1,22	1,12	1,00	0,87	0,71	–	–	–	–	–	–
70	1,18	1,10	1,00	0,89	0,77	0,63	–	–	–	–	–
75	1,15	1,08	1,00	0,91	0,82	0,71	0,58	–	–	–	–
80	1,13	1,07	1,00	0,93	0,85	0,76	0,65	0,53	–	–	–
85	1,12	1,06	1,00	0,94	0,87	0,79	0,71	0,61	0,50	–	–
90	1,10	1,05	1,00	0,94	0,88	0,82	0,74	0,67	0,58	0,47	–
95	1,10	1,05	1,00	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45

16.8.2.6 In choosing the cables for final branch circuits of lighting and cooking appliances correction factors or simultaneity factors are not applicable.

16.8.2.7 The cables shall be so designed that they could withstand maximum short-circuit current occured in the circuit considering time and current ratings of the protective devices and peak value of the prospective short-circuit current of the first onehalf period.

16.8.2.8 Cables installed in parallel and belonging to the same phase or pole shall be of the same type, be laid together and have the same cross-sectional area of at least 10 mm^2 and the same length.

16.8.3 Selection of cable cross-sectional areas for permissible voltage drop.

16.8.3.1 Voltage drop on the cable connecting the generators of the main switchboard or the emergency switchboard shall not exceed 1 %.

16.8.3.2 Voltage drop between busbars of the main or emergency switchboard and any points of the installation shall not exceed 6 % of the rated voltage under normal operating conditions; for consumers supplied from the accumulator battery with the rated voltage up to 50 V this value may be increased to 10 %.

For circuits of navigation lights it may be required to limit the voltage drop by a lesser value in order to ensure necessary luminous intensity.

At short-term loads (e.g. when starting the electric motors) the greater voltage drop may be permitted if it does not cause disturbance of normal operation of the ship's electrical installation.

16.8.3.3 The cables used for feeding the directly-started alternating current electric motors shall be computed in such a manner that the voltage drop on motor terminals at starting is not over 25 % of the rated voltage.

16.8.4 Installation of cables.

16.8.4.1 Cables shall be installed in runs, which shall be, as far as possible, straight and accessible.

The cable runs shall pass through locations where cables are not exposed to oil, fuel, water and excessive external heating.

Cable runs shall be installed not closer than 100 mm to sources of heat.

16.8.4.2 No cables shall be installed at a distance less than 50 mm from the double bottom and from the fuel and oil tanks.

Cable runs shall be installed at a distance not less than 20 mm from the shell plating, as well as from fireproof watertight and gastight bulkheads and decks.

16.8.4.3 For bunches of cables consisting of cable types, which have not been subjected to a bunch fire test, the following measures shall be taken during installation to limit the propagation of fire:

.1 fire-retarding divisions shall be used, B-0 class at least, (refer also to **2.1.2.5**, Part VI "Fire Protection") where bunches enter the main and emergency switchboards, central control stations and consoles for the main propulsion plant and for important auxiliaries, as well as at each entry and exit point of cable runs in fully enclosed metal conduits 16.8.4.3,***a***);

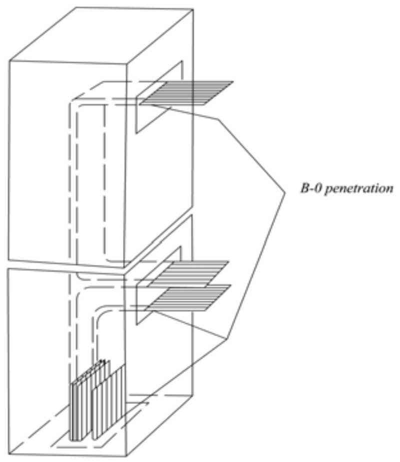


Fig. 16.8.4.3,***a***. Fully enclosed cable run protected with B-0 fire-retarding divisions

.2 in closed and semi-enclosed rooms and spaces, bunches installed in partly enclosed and open cable runs shall be protected by: flameproof coatings over the entire length of vertical cable runs and over a length of 1 m every 14 m apart on horizontal cable runs (Fig. 16.8.4.3,***b***), or B-0 fire-retarding divisions at least at every second deck or every 6 mm apart for vertical cable runs and every 14 m apart for horizontal cable runs (Fig. 16.8.4.3,***c***).

Fire-retarding divisions shall be made of steel plates at least 3 mm thick and having dimensions as shown in Fig. 16.8.4.3,***c***;

.3 bunches installed in cargo holds shall be protected by B-0 fire-retarding divisions at least at the entry and exit points of cable runs.

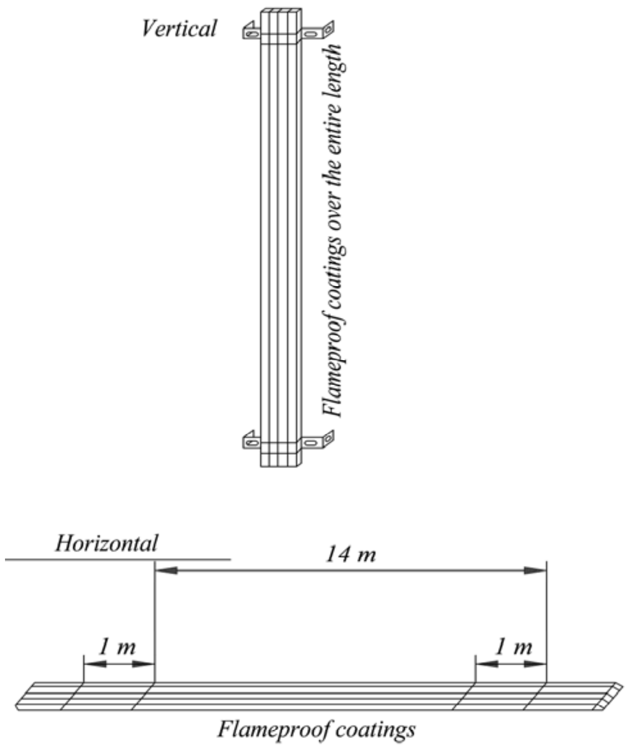


Fig. 16.8.4.3,***b***. Cable runs protected with flameproof coatings

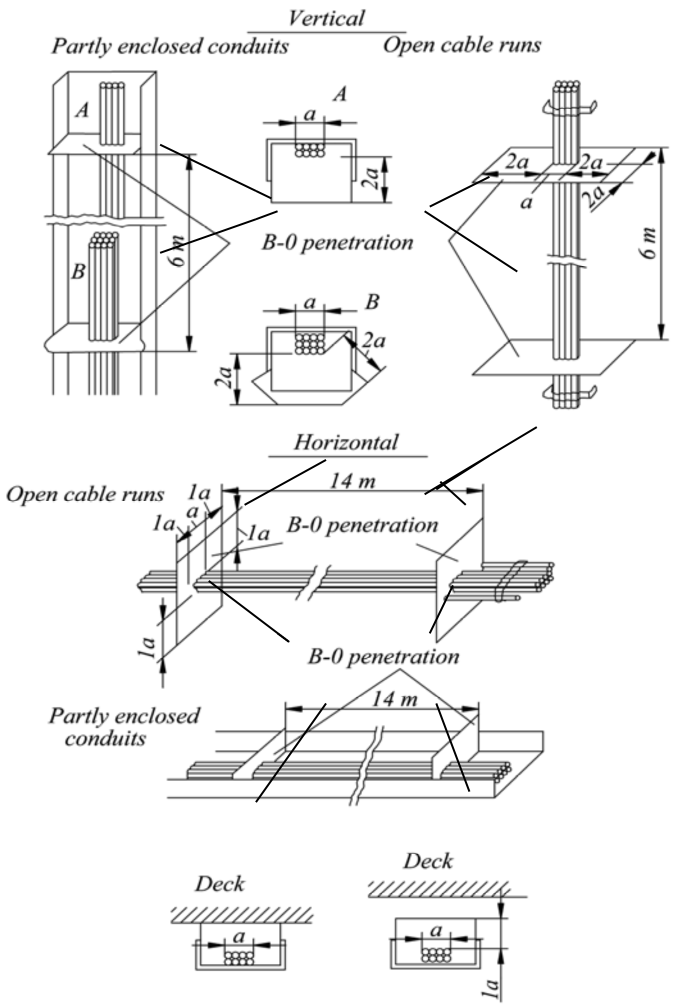


Fig. 16.8.4.3,*c*. Cable runs protected with B-0 fire-retarding divisions

16.8.4.4 Cables having external metallic sheaths may be installed on structures of light metal or be fastened in position by means of cable clips of light metal only in cases where reliable anticorrosive protection is provided.

16.8.4.5 In the holds of dry cargo ships intended for the carriage of dangerous cargoes, no through runs of cables shall, generally, be installed.

Where such cable-laying is necessary the requirements of **2.9** shall be fulfilled.

16.8.4.6 Cables installed in fishing vessels at locations subjected to the action of salt shall be adequately protected with casings or be provided with salt-resistant sheaths.

16.8.4.7 No cables are recommended to be installed under the flooring of machinery spaces. If such installation is required, cables shall be laid in metallic pipes or in closed conduits (refer to **16.8.8**).

16.8.4.8 Cables installed across expansion joints in the hull structure shall be provided with expansion loops having a radius adequate for such joint. The inside diameter of a loop shall not be less than 12 outside diameters of the cables.

16.8.4.9 Installation of cables having insulation intended to withstand different permissible temperatures in the common cable runs shall be effected in such a manner that the cables are not heated above their permissible temperature.

16.8.4.10 Cables with different protective coverings the less hard of which may be damaged shall not be installed in one common pipe, one common duct or in other runs of not supported common laying.

16.8.4.11 Cores in multi-core cables shall not be used for supplying power and control currents to essential services not associated with one another.

Multi-core cables shall not be used simultaneously for safety voltage and service voltages exceeding the safety level.

16.8.4.12 When machinery is energized through two separate feeders, these feeders shall be installed in different runs as far apart as possible in horizontal and vertical directions.

16.8.4.13 When installing cables in ducts or other structures of combustible material, the ways of cable installation shall be protected from igniting by means of suitable fire protection, such as lining, coating or impregnation.

16.8.4.14 Cables shall not be embedded into thermal or acoustic insulation in case it is made of combustible materials.

Cables shall be separated from such insulation by the lining of noncombustible materials or shall be installed at a distance at least 20 mm from it.

When cables are laid in thermal or acoustic insulation made of combustible materials, they shall be computed with relevant reduction in current rating.

16.8.4.15 Cables installed in refrigerated spaces shall be provided with protective sheath of metal, polychloroprene composition, or of any other material resistant to the exposure of the cooling agent.

If cables are provided with armour, this armour shall be adequately protected against corrosion.

16.8.4.16 Cables in refrigerated spaces shall be installed on perforated panels or bridges and fastened in position in such a manner that a free space is reserved between the cables and the walls of the room.

Panels, bridges and cable clips shall be protected against corrosion.

If cables cross the thermal insulation of a refrigerated space, these cables shall run at right angles through an appropriate gland pocket on both ends.

16.8.4.17 When installing the cables, minimum internal bending radii shall be maintained in accordance with Table 16.8.4.17.

Minimum internal bending radii of high-frequency data transfer cables shall be at least 8 external diameters for unscreened and 10 external diameters for screened cables.

16.8.4.18 Cables and earthing conductors of equipment mounted on shock absorbers shall be installed in such a manner that they cannot be damaged in service.

16.8.4.19 Cables laid on the open parts of the ship and masts shall be protected against direct exposure to sun radiation.

16.8.5 Fastening of cables.

16.8.5.1 Cables shall be adequately fastened in position by means of clips, holders, hangers, etc., manufactured of metal or other non-combustible material. The fastener surface shall be sufficiently wide and to have no sharp edges. The fasteners shall be selected in such a manner that the cables are securely fastened in position without damage to their protective coverings.

Table 16.8.4.17

Type of cable		**External diameter of cable, in mm**	**Minimum bending radius of cable**
Insulation material of cable	**Protective covering of cable**		
Rubber or polyvinylchloride	Armoured with metal tape or wire	Any	10*d*
	Protected with metal sheath	Any	6*d*
	Lead alloy and armour	Any	6*d*
	Other sheaths	Up to 9,5	3*d*
		9,5 - 25,4	4*d*
		Over 25,4	6*d*
Varnished cambric	Any	Any	8*d*
Mineral insulation	Metal	Up to 7	2*d*
		7 - 12,7	3*d*
		Over 12,7	4*d*
Ethylene-propylene rubber or cross-linked polyethylene	Semiconducting and/or metal	25 and over	10*d*

16.8.5.2 Distances between cable fastening points in case of horizontal installation shall not exceed the values given in Table 16.8.5.2.

When laying cable runs on cable ladders inside spaces the distance between cable fastening points may be enlarged up to 900 mm.

Meanwhile, the distance between the supports of cable runs (ladder rung) shall not exceed 400 mm. For vertical runs of cables these distances may be increased by 25 %.

Table 16.8.5.2

External diameter of cable, mm		**Distance between fastening points for cables, mm**		
over	up to	without armour	with armour	with mineral insulation
–	8	200	250	300
8	13	250	300	370
13	20	300	350	450
20	30	350	400	450
30	–	400	450	450

16.8.5.3 Cables shall be fastened in such a manner that mechanical strains in cables, if any, are not transmitted to their inlets or connections.

16.8.5.4 Cable runs and cables installed parallel to shell plating shall be fastened to ship's structures.

On watertight bulkheads and masts, cables shall be fastened on special supports (saddles, tray plates, chocks, etc.).

16.8.5.5 Cables running parallel to bulkhead subject to sweating shall be installed on bridges or on perforated panels in such a manner that free space is reserved between cables and bulkheads.

16.8.5.6 Cable runs shall be installed with a minimum number of crossings. Bridges shall be used at places where cables cross each other. An air gap of not less than 5 mm shall be left between the bridge and the cable run crossing it over.

16.8.5.7 For ships constructed from non-conducting materials it is permitted, due to the technology of hull construction from these materials, the properties of the materials used, etc., to accept the equivalents to the requirements for the installation, fastening and sealing of penetrations of cables and cable runs specified in the Rules for steel ships.

16.8.6 Cables penetrating decks and bulkheads.

16.8.6.1 Cable penetrations through watertight, gastight and fire-resisting bulkheads and decks shall be sealed.

Sealings where cables penetrate through the above bulkheads and decks shall not reduce their tightness; no force shall be transmitted to cables resulting from elastic deformations of ship's hull.

16.8.6.2 When installing the cable through nontight bulkheads or elements of ship's structure less than 6 mm thick, linings or bushings that will prevent damage to cables shall be provided.

When bulkheads or ship's structure is 6 mm or more thick, no linings or bushings are required, but the edges of holes shall be rounded.

16.8.6.3 Installation of cables over watertight decks shall be effected by one of the following methods:

.1 in metal pipes (shafts) protruding above the deck to a height of not less than 900 mm in locations where mechanical damage to cable is possible and to a height not less than that of the door sill in spaces where there is no risk of such damage;

.2 in common metal sockets or boxes with additional protection of cables by enclosures having the height specified in **16.8.6.3.1**.

Cable boxes shall be packed with cable compound, while the pipes shall be provided with glands or be stuffed with cable compound.

16.8.6.4 Internal cross-section of each penetration shall be filled with cables to not more than 40 %.

For module packing systems the extent of filling the penetration shall be determined in accordance with the approved design.

16.8.7 Packing compounds.

16.8.7.1 To fill the cable boxes in watertight bulkheads and decks, the use shall be made of packing compounds having good adhesion to the inside surfaces of cable boxes and cable sheath that will withstand the action of water and oil products, will not shrink and lose its tightness in continuous service under conditions specified in **2.1.1** and **2.1.2**.

16.8.7.2 Packings of cable penetrations through fire-resisting bulkheads shall withstand standard fire test specified for the given type of bulkhead in **2.1.2**, Part VI "Fire Protection".

16.8.8 Installation of cables in pipes and conduits.

16.8.8.1 Metallic pipes and conduits wherein cables are installed shall be protected from corrosion on the inside and the outside surfaces. The inside surface of pipes and conduits shall be even and smooth. Ends of pipes and conduits shall be machined or protected in such a manner that no damage is caused to the cables when they are being pulled in.

Cables with lead sheaths not having any additional protective covering shall not be installed in pipes and conduits.

16.8.8.2 Pipe bending radius shall not be smaller than the permissible radius for cable of the largest diameter installed in this pipe (refer to **16.8.4.18**).

16.8.8.3 The total cross-sectional areas of all cables measured on their outside diameters shall not exceed 40 % of the inside cross-sectional area of the pipe and the conduit.

16.8.8.4 The pipes and conduits shall be mechanically and electrically continuous and securely earthed if the earthing has not been already effected by the method itself of pipe and conduit installation.

16.8.8.5 The pipes and conduits shall be installed in such a manner that no water can accumulate therein. When required, ventilation holes shall be provided in the pipes and conduits, as far as possible, in the highest and lowest points, so that circulation of air is ensured and vapour condensation is prevented.

Holes in pipes and conduits are permissible only at places where it will not enhance the danger of explosion or fire.

16.8.8.6 Cable pipes and conduits installed alongside ship's hull, which can be damaged due to deformation of ship's hull, shall be provided with compensation devices.

16.8.8.7 If in accordance with **16.8.1.1**, the use is allowed of cables with combustible covering, these cables shall be installed in metallic pipes.

16.8.8.8 Cables installed in pipes and conduits vertically shall be fastened so that they are not damaged under tension due to gravity.

16.8.8.9 It is allowed to use cable trays/protective casings of the approved type made of reinforced and plain thermoplastic polymeric materials like polyvinylchloride (PVC) or fiber reinforced plastic (FPR). The protective casing shall have round or other closed cross-section.

16.8.8.10 Cable trays/protective casings made of polymeric materials shall be supplemented by metallic fixing and straps such that in the event of a fire they, and the cables affixed, are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route.

When cable trays/protective casings made of polymeric materials are used on open deck, they shall additionally be protected against UV radiation..

16.8.8.11 The load on the cable trays/protective casings made of polymeric materials shall be within the safe working load (SWL).

The support spacing shall not be greater than the manufacturer's recommendation nor in excess of spacing at the SWL test. In general the spacing shall not exceed 2 m. The selection and spacing of cable tray/protective casing supports shall take into account:

cable trays/protective casings' dimensions;

mechanical and physical properties of their material;

mass of cable trays/protective casings;

loads due weight of cables, external forces, thrust forces and vibrations;

maximum accelerations to which the system may be subjected;

combination of loads.

16.8.8.12 The sum of the cables installed in cable trays/protective casings made of polymeric materials total cross-sectional area shall not exceed 40 % of the protective casing's internal cross-sectional area. This does not apply to a single cable in a protective casing.

16.8.9 Special precautions for single-core cables for a.c. wiring.

16.8.9.1 A.c. wiring shall not be carried out, as far as possible, in single-core cables. When, however, it is necessary to use single-core cables for circuits rated in excess of 20 A, the following precautions shall be observed:

.1 the cables shall be armoured with non-magnetic material;

.2 cables belonging to one circuit shall be placed in the same run or metal pipe and shall be as short as practicable.

Each of such cables may be installed separately under a non-magnetic screen (in a pipe) earthed at one point and isolated from the screens of other cables and from the hull;

.3 cable clamps, unless they are made of non-magnetic material, shall include all the single-core cables of a circuit;

.4 the distance between the cables shall not be greater than one cable diameter.

16.8.9.2 Where single-core cables pass through bulkheads or decks, there shall be no magnetic material between cables belonging to the same circuit.

The clearance between the cables and the magnetic material shall not be less than 50 mm.

16.8.9.3 When single-core cables having a current rating greater than 250 A are installed near steel structures, the clearance between the cables and the structure shall be at least 50 mm.

16.8.9.4 When single-core cables of a conductor cross-section of 185 mm^2 or over are installed, a transposition of phases shall be effected at intervals not exceeding 15 m.

Where cable length is below 30 m, no transposition is necessary.

16.8.9.5 Multicore cables with conductors in parallel shall be installed as single-core cables, and all the requirements for single-core cables apply in this case.

16.8.10 Connection and tapping of cables.

16.8.10.1 Ends of rubber-insulated cables to be introduced into machines, apparatus, switchgear and other equipment shall be provided with contact, protection and packing terminals that will ensure reliable electrical contact, will not permit moisture to penetrate inside the cable and will protect the insulation of cable cores from mechanical damage and effects of air and oil vapours.

At places of connection, rubber-insulated cable cores shall be provided with protective insulation against damage (wear, etc.).

16.8.10.2 Protective covering of a cable inserted into a device shall enter not less than 10 mm inside.

16.8.10.3 At places of tappings, connection of cables shall be effected in junction boxes by means of clamps.

16.8.10.4 If during the installation of cables it is necessary to make additional connections, these shall be effected in suitable junction boxes provided with clamps.

The joint as a whole shall be protected from ambient conditions. Other methods of cable connection approved by the Register may be allowed.

17. ELECTRIC PROPULSION PLANTS

17.1 GENERAL

17.1.1 The requirements of this Section apply to all electric propulsion plants and their equipment, as well as to manufacture, installation and tests including:

.1 generators and their prime movers;

.2 switchboards;

.3 transformers/reactors;

.4 semiconductor frequency converters;

.5 electric propulsion motors;

.6 excitation arrangements (units);

.7 arrangements (units) of control systems of electric propulsion plants, monitoring systems (alarm system, indication and logging systems), as well as safety devices;

.8 power bus ducts and cable runs of production systems and power distribution in electric propulsion plants.

17.1.3 If an electric propulsion plant is installed on board a ship, it shall comply with the requirements of this Section and applicable requirements of other Sections of this Part.

At that, the distinguishing mark EPP shall be added to the class notation in compliance with the requirements of **2.2.12**, Part I "Classification".

17.1.4 The electrical equipment of the electric propulsion plant shall meet the requirements of other sections and chapters of this Part unless otherwise specified in this Section.

17.1.5 In electric circuits of electric propulsion plants the voltage used shall not exceed those specified in **4.2** and Section 18.

17.1.6 It is recommended to provide electric heating in spaces enclosing electrical machines, switchboards and control panels.

17.1.7 Stationary lighting shall be provided underneath generators and motors of the electric propulsion plant.

17.1.8 Parts of electric propulsion machines (motors and generators) located under the floor shall have the degree of protection not below IP56.

Where they are installed in a dry compartment or protected against the ingress of water by a watertight foundation, and additionally, an alarm operating with the ingress of water in that compartment is provided, degree of protection IP23 may be allowed.

17.1.9 Provisions shall be made for arrangements preventing the generation and accumulation of moisture and condensate, in particular, while being idle for a long time, in casings of electric propulsion motors, generators, semiconductor frequency converters and other electric propulsion plant components. These arrangements may be electric heaters, air dryers, etc.

17.1.10 Electric propulsion plant shall be fitted with an arrangement for insulation resistance monitoring complying with the requirements of **2.11**.

17.2 DEFINITIONS AND EXPLANATIONS

17.2.1 For the purpose of this Section the following definitions and explanations have been adopted:

Azimuth drive drive which moves the propulsion unit around the vertical axis.

Main control station of the electric propulsion plant - control station of the main propulsion plant which is attended under seagoing condition.

Electric propulsion plant - set of equipment for distribution and conversion of electrical power into mechanical one in order to reproduce a predetermined torque by one or more propeller propulsions.

Double sensor - sensor with two sensor elements in one housing.

Unified electric power plant - electric power plant united with the propulsion plant which ensures ship propulsion.

Local control station - control station located where a system intended for selection and input of reference values for semiconductor frequency converters or electric propulsion system external devices (units) control intended for semiconductor frequency converters which is independent from reference values for remote control system and any external are installed.

Podded drive - propulsion plunt in which the electric propulsion motor is located in a dedicated, submerged unit (pod housing) of the ship.

Redundant sensor - two single sensors in separate housings to control the same parameter.

Electric propulsion system - coherent set of interrelated functional units implemented in electric power plant, interacting with a source of electric power to control the focus with the specified dynamic performance and set algorithms.

17.3 CONFIGURATION OF ELECTRIC PROPULSION PLANTS

17.3.1 The electric propulsion plant supplied from and using a.c. electrical power includes the following devices:

.1 a.c. main generators with their control devices – at least 2;

.2 main switchboard separated in two parts with a section circuit breaker or break switch;

.3 power transformers for a galvanic isolation or conversion of the main switchboard voltage to that of semiconductor frequency converter – one per each converter;

.4 power semiconductor frequency converters to supply the electric propulsion motor — at least 2;

.5 arrangements (units) of control or controller of electric propulsion plants – at least 2;

.6 electric propulsion motor – one or more.

17.3.2 For electrical propulsion plants with one electric propulsion motor, synchronous, asynchronous and electronically commutated main propulsion motors shall have two systems of stator windings supplied from the relevant semiconductor frequency converter.

Each converter shall be designed for at least 50 % of the rated power of the electric propulsion plant. If the ship is equipped with several electric propulsion motors at the common shaft with the propeller of the main electric propulsion plant or with several main propulsion plants, the use of electric propulsion motors with one system of stator windings is permitted.

17.3.3 Propulsion d.c. motors shall be of the double-armature (double-commutator) type with each armature winding designed for at least 50 % of the rated power of the plant.

Each armature winding shall be supplied from its independent converter. Any single failure in one converter shall not result in complete loss of power.

17.3.4 Provision shall be made for braking or locking devices as part of the shafting to prevent its free rotation with a switched-off propulsion motor (shaft) at any environmental conditions or during ship towing.

17.3.5 Electric propulsion system structure and control algorithm provided by some electric propulsion plants shall follow the one failure principle, i.e. if any component of the electric propulsion plant fails, a ship shall be underway at least at the partial power.

17.3.6 Provision shall be made for a warning alarm at all active control stations when any failure occurs in the electric propulsion plant.

17.3.7 For all auxiliary machinery and essential services, provision shall be made for local control stations to which control is transferred if the remote automated control system of the electric propulsion plant fails.

17.3.8 Configuration of electric propulsion plant supplied with and using d.c. electric power is specified in **22.8.1**.

17.4 EXCITATION SYSTEMS

17.4.1 General.

17.4.1.1 Every excitation system shall be supplied by a separate feeder.

The obtainable current and voltage of the excitation system, as well as source of power shall fully comply with the requirements for all electric propulsion plant modes including manoeuvring, overcurrent and short circuit, as well as the capsizing moment conditions.

17.4.1.2 Power supply of excitation systems shall be protected against short circuits only.

The activation of an electromagnetic release at short circuit shall be supplemented with an alarm at control stations.

17.4.1.3 If the built-in short-circuit monitoring device of the excitation system trips, the respective circuit breaker of the generator or propulsion motor shall also trip.

17.4.1.4 If the excitation system is fitted with independent safety devices against underfrequency and over-voltage or U/f-functions, they shall be adjusted in such a way that the system protection reacts first.

17.4.1.5 Excitation circuits shall be provided with means for suppressing voltage rise when an excitation switch is opened (field suppression system).

17.4.1.6 Means (filters, etc.) shall be provided to limit harmonic distortions and reduce a power factor.

17.4.2 Generator excitation.

17.4.2.1 Excitation systems shall be supplied from the generator, the generator shall be self-excited. The voltage built up shall be done without the aid of external sources of electrical power.

17.4.2.2 External source of electrical power may be used for exciter control circuits, as well as for initial excitation, provided it is redundant.

The external source of power shall be supplied from the main and emergency switchboards and, additionally, from the standby accumulator battery.

At least two external sources of power for all electric propulsion plant generators shall be provided.

17.4.3 Electric propulsion motor excitation.

17.4.3.1 The exciter shall be supplied directly from the same main switchboard section supplying the stator winding.

17.4.3.2 Excitation systems and automatic control systems shall protect electric propulsion motors from overspeeding in the event of the propeller breaking down or working clear of water.

17.5 ELECTROMAGNETIC COMPATIBILITY (EMC)

17.5.1 The electric propulsion plant shall operate without malfunctions and failures being exposed to electromagnetic interference, and comply with the requirements of **2.2**.

17.5.2 Equipment producing transient voltage, frequency and current variations shall not cause malfunctions and failures of other equipment on board, neither by conduction, induction or radiation.

17.5.3 If a total harmonic distortion value of 10 % is exceeded when operating the propulsion plant, the appropriate filtering and interference-free operation of any consumers shall be ensured.

17.6 PRIME MOVERS OF ELECTRIC PROPULSION PLANT GENERATORS

17.6.1 Permissible speed deviations.

17.6.1.1 If electric propulsion plant generators are also used for supplying the ship network, frequency deviations with the relevant load variations shall meet the requirements specified in **2.11.3**, Part IX "Machinery".

17.6.1.2 Where the speed control of the propeller requires speed variation of prime movers of the electric propulsion plant generators, the governors shall be provided with means for local control as well as for remote control.

17.6.1.3 The prime movers rated power and overload capacity of the Unified Electric power plant generators shall be adequate to supply the power needed in the range of the operating conditions of the electrical equipment, as well as the electric propulsion plant load variations due to manoeuvring, at sea, including severe weather conditions.

17.6.2 Parallel operation.

17.6.2.1 In case of parallel operation of generators, the control system used shall ensure stable proportional distribution of loads over the entire output range of the prime movers as specified in **3.2.2**.

17.6.2.2 In case the unified electric power plant generators (shaft generators) are used simultaneously for power supply and the electric propulsion plants containing reversible semiconductor frequency converters adapted to recover the power at braking of the electric propulsion motor and to retard the speed of the electric propulsion motor in reverse, the power plant control system ыshall ensure transmitting data on consumed active power from generators to define switching threshold of baking resistors shall be provided.

17.6.3 Reverse power.

17.6.3.1 When the propulsion motor is braking or reversing in emergency from full ahead running to full speed astern, the prime movers of an independent electric propulsion plant shall be capable of absorbing a proportion of the recuperated energy without stripping due to overspeed, as is specified in **2.11.6**, Part IX «Machinery», or reverse power.

17.6.3.2 To absorb a proportion of the recuperated energy and to retard the speed of the electric propulsion motor of an independent electric propulsion plant, braking resistors may be used ensuring the necessary limits on the prime movers and the electric propulsion plant generators speed. The amount of recuperated work shall be limited by DMS controllers.

17.7 ELECTRIC PROPULSION PLANT GENERATORS

17.7.1 General.

17.7.1.1 Generators (shaft generators) operating with semiconductor converters shall be designed for the expected harmonics of the system.

While designing the electric power plant and selecting the generators' rated power, a sufficient output reserve shall be provided to prevent the generator temperature rise, compared with the sinusoidal load.

17.7.1.2 Stator windings of generators with rated power output above 500 kVA shall be provided with temperature sensors.

17.7.1.3 Electric propulsion plant generators shall be fitted with cooling air cleaning filters opencircuit and closed-circuit ventilation.

For alternating current brushless generators with closed-circuit ventilation the cooling air cleaning filters are not mandatory.

Ventilation ducts shall be arranged so as to prevent water ingress into the machine.

17.7.1.4 Electric propulsion plant generators may be used for supplying auxiliary electrical machinery and services provided voltage and frequency are stable under all conditions, including manoeuvring, in compliance with the requirements of **2.1.3**.

17.7.1.5 No circuit breakers shall be fitted in excitation circuits of generators except those which remove excitation of machinery at short circuits or damages in the main current circuit.

17.7.1.6 Means of protection of generators shall comply with the requirements specified in **8.2**. For generators with the ratings more than 1500 kVA, protection against internal faults shall be provided.

17.7.2 Generator bearings and lubrication.

17.7.2.1 Sliding bearing shells shall be easily replaceable. Provision shall be made for checking the bearing lubrication. Adequate lubrication shall be provided even at the maximum potential trim. Provision shall be made for relevant seals to prevent oil ingress inside the generator.

17.7.2.2 In case of bearings with forced lubrication (under pressure), the following alarms, as a minimum, shall be provided at the electric propulsion plant control stations:

.1 failure of lubricating system (no flow of lubricating oil, failure of lubrication pump, loss of pressure in the lubrication pipe, etc.);

.2 maximum temperature of each bearing.

17.7.2.3 Generators shall be fitted with backup (emergency) devices for bearings lubrication which, in the event of malfunction or failure of the main (working) lubricating system, provide adequate lubrication until the machine full stop.

17.7.2.4 To avoid damage to bearings, provision shall be made to ensure that no currents can flow between the bearing and the shaft.

17.7.3 Generators cooling.

17.7.3.1 In addition to thermometers, temperature sensors of cooling air shall be provided which shall initiate an alarm with the excess of a permissible temperature.

17.7.3.2 For machines with a closed circuit cooling and heat exchanger, the flow of primary and secondary coolants shall be monitored. An alarm shall be initiated with the flow failure.

17.7.3.3 Leakage-water and condensed moisture shall be kept away from the machine windings. Provision shall be made for an alarm to monitor leakage.

17.8 ELECTRIC PROPULSION PLANT SWITCHBOARDS

17.8.1 Electric propulsion plant switchboards shall meet the requirements of **4.6** and **18.6**.

17.8.2 Electric propulsion plant system shall be fitted with an arrangement for insulation resistance monitoring (refer to **2.11**).

17.8.3 Switches for routine switching in de-energized circuits of the electric propulsion plant shall be provided with an interlocking device to prevent their tripping under voltage, or false switching.

17.9 ELECTRIC PROPULSION PLANT POWER TRANSFORMERS

17.9.1 General.

17.9.1.1 Transformers and reactors shall meet the requirements of Section **11** and **18.4**.

17.9.1.2 Provision shall be made for at least two independent power transformers for the electric propulsion plant. Only transformers with separate windings shall be used.

17.9.1.3 The winding temperatures of transformers used in electric propulsion plants shall be monitored with a sensor and indicator system.

17.9.1.4 For current measurements on the primary side in each phase supplying the electric propulsion plant transformer, ammeters shall be provided on the main switchboard.

17.9.1.5 Each electric propulsion plant transformer shall have overcurrent and short circuit protection on the primary and secondary side.

For protection on the secondary side, electric propulsion plant semiconductor converter may be used.

17.9.2 Liquid cooled electric propulsion plant transformers.

17.9.2.1 Windings of liquid cooled transformers shall be completely covered by liquid, even for inclinations up to and including 22,5°.

17.9.2.2 Transformers shall be provided with the necessary collecting and accumulating arrangements for coolant leaks.

Fire detectors and fire-fighting equipment shall be installed in the vicinity of the transformer. The firefighting equipment may be manually operated.

17.9.2.3 Transformers shall be fitted with protection against gassing of coolant.

17.9.2.4 The coolant temperature shall be monitored with a sensor system. A pre-alarm shall be actuated before the maximum permissible temperature is attained.

When the maximum permissible temperature limit is reached, a separate sensor shall activate protection which switches off the transformer.

17.9.2.5 The coolant level shall be monitored by two sensors, one of them shall actuate an alarm and the other set up to the maximum permissible level shall switch off the transformer.

17.9.3 Air cooled electric propulsion plant transformers.

17.9.3.1 The operation of fans for transformers cooling, as well as the cooling air temperature shall be monitored with a sensor system.

An alarm shall be given at the excess of temperature or fan failure.

17.9.3.2 Where a closed circuit cooling air system with an air cooler is used, in addition to the requirements of **17.9.3.1**, the following shall be monitored:

.1 the minimum flow of primary and secondary coolants (air and water);

.2 heat exchanger leakage to be alarmed.

The heat exchanger shall be so installed that water leakages and condensed moisture are kept away from the windings.

17.10 ELECTRIC PROPULSION PLANT SEMICONDUCTOR CONVERTERS

17.10.1 General.

17.10.1.1 Converters shall meet the requirements of Section **12**.

17.10.1.2 At least two entirely independent separate semiconductor converters shall be provided to feed separate winding systems of electric propulsion plant (or separate electric propulsion plants).

17.10.1.3 Each converter shall be provided with a separate unit or a control system.

17.10.1.4 There shall be provided two galvanically isolated speed sensors for each unit or device of control system. Common housing of both sensors is permitted.

17.10.1.5 If the converter feeds a permanently excited electric propulsion motor of direct of alternative current (including those of permanent magnet), a switch disconnector shall be fitted in the "motor - converter" line which opens automatically in case of an inverter or rectifier fault. Devices shall be provided for such faults diagnosis.

17.10.1.6 Electric propulsion plant converters shall be designed for the nominal torque of the drive (nominal torque at a propeller shaft). Short – term overloads and speed variations (dips) resulting from overloads or the load throwing off at propeller emergence shall not lead to the activation of converter protection.

17.10.1.7 The recuperated energy may be received to the unified electric power plant at retarding the speed of the electric propulsion motor in reverse via the reversible semiconductor frequency converters to ensure the quality parameters (refer to 2.1.3) for the ship's power consumers.

The excess of the recuperated energy shall be absorbed by "braking resistors".

17.10.1.8 Reactive power may be compensated by means of reversible semiconductor frequency converters. Thus, the control unit shall receive a signal from control system of the electrical power plant to comply with the current value of the reactive power being generated by the power consumers of the unified electric power plant.

17.10.1.9 The cabinets for semiconductor converters shall meet the requirements of **4.6** and Section **18**.

17.10.1.10 The design of the cabinets for semiconductor converters shall provide for the quick exchange of power components of the built-in equipment.

This may be achieved by use of modular design for power circuit, its components, control, protection and data display units.

17.10.1.11 Requirements for semiconductor converters of the electric propulsion plant in the systems with electrical power distribution for direct current are specified in **22.8.2**.

17.10.2 Cooling of semiconductor converters.

17.10.2.1 If converters are fitted with a forced-cooling system, means for its monitoring shall be provided.

In case of a failure of the cooling system, measures shall be taken to prevent the overheat and failure of the converter.

17.10.2.2 The cooling system shall be provided with an alarm system. The alarm signal shall be generated by the reducing of a coolant flow or by high temperature of semiconductors.

17.10.2.3 Single failures in the converter cooling system shall not result in tripping all converters of the ship's electric propulsion plant.

17.10.3 Protection of semiconductor converters.

17.10.3.1 Operational overvoltages in a supply system of converters shall be limited by suitable devices to prevent breakdown of the components of the semiconductor frequency converters power circuit.

17.10.3.2 A suitable control system shall ensure that the rated current of semiconductor elements cannot be exceeded under all normal and most severe conditions.

17.10.3.3 Power circuit and the converter components shall be protected against damage and failure due to direct short-circuit at the terminals.

Protection by fuses against short - circuit currents is permitted. The relevant feedbacks of the converter shall control (limit) the current in such away, that no components are damaged when the converter is switched on to a blocked motor.

17.11 PROTECTION ARRANGEMENTS FOR HARMONIC FILTERS

17.11.1 A harmonic filter maintaining harmonic distantion levels within acceptable limit shall be arranged as a three phase unit with individual protection of each phaseon the main switchboard busbars at any step of propulsion.

17.11.2 Each individual filter circuits shall be protected against overcurrents and short-circuit currents. The fuses in filter circuits shall be monitored. Any fuse burnout shall be alarmed.

17.11.3 When designing and using line filters, their layout shall be designed for any conceivable line constellations. In particular, self-resonance shall be excluded under any load conditions and operating generators constellations.

17.11.4 In case of several parallel filter circuits, the current symmetry shall be monitored.

An unsymmetrical current distribution in the individual filter circuits and the failure of the filter shall be alarmed.

17.11.5 Consideration shall be given to additional protection for the individual capacitor element (e.g. relief valve or overpressure disconnector) in order to protect against damage from rupturing. This consideration shall take into account the type of capacitors used.

17.11.6 Additional requirements for protection arrangements for harmonic filters in systems with electrical power distribution for direct current are specified in **22.8.3**.

17.12 ELECTRIC PROPULSION MOTORS

17.12.1 General.

17.12.1.1 Stator windings of a.c. motors and interpole, mainpole and compensation windings of d.c. motors of electric machines with a capacity above 500 kW, shall be provided with temperature sensors.

17.12.1.2 Regarding the design and lubrication of electric propulsion motor bearings, the requirements of **17.7.2** shall be met.

17.12.2 Electric propulsion motors cooling.

17.12.2.1 The cooling system shall ensure sufficient cooling under all load and speed conditions.

17.12.2.2 Electric propulsion motors shall be fitted with built-in temperature sensors which shall give an alarm signal with the excess of a permissible temperature.

17.12.2.3 For machines with a closed circuit cooling system and a heat exchanger, the flow of primary and secondary coolants shall be monitored.

17.12.2.4 Provision shall be made to alarm leakage. The heat exchanger shall be installed so that water leakages and condensed moisture are kept away from the windings.

17.12.2.5 If the cooling system of the propulsion motor fails, the emergency operation mode to ensure ship's manoeuvring under heavy navigating conditions shall be provided. Interventions by an operator for opening of emergency air flaps are permitted.

17.12.2.6 Air-cooled electric propulsion motors shall be fitted with air intake filters and two forced-air fans, each having a capacity sufficient for normal operation of the electric motor.

A visual signal indicating fans operation and an alarm on their shutdown shall be provided.

17.12.2.7 A liquid cooling system for multi-armature machines shall be independent for each armature.

17.12.3 Protection of electric propulsion motor.

17.12.3.1 Over-current protection in the main and excitation circuits shall be set sufficiently high so that there is no possibility of its operating due to the over-currents caused by ship's maneuvering, operation in heavy seas or in broken ice.

17.12.3.2 Short-circuit and overcurrent protection may be provided by the converter. Different electric propulsion motor designs (d.c. synchronous, induction and permanent-magnet excitation motors) shall be taken into consideration.

Additional requirements for the protection of electric propulsion motor in the systems with electrical power distribution for direct current are specified in **22.8.4**.

17.12.3.3 For electric propulsion d.c. motors provision shall be made for an independent overspeed (runaway) protection device as required in **2.11**, Part IX "Machinery".

The electric propulsion motor shall be capable to withstand overspeed up to the limit reached in accordance with the characteristics of the overspeed protection device at its specified operational setting.

17.12.3.4 The motor shall be capable to withstand a sudden short-circuit currents at its terminals under nominal load without damage.

Steady state short-circuit current of a permanent excited motor shall not cause thermal damages of the motor and the current carrying components (e.g. slip rings, cables, feeders or busducts)**.**

17.13 SPECIAL REQUIREMENTS FOR PODDED AZIMUTH THRUSTER DRIVES AND STEERABLE PROPELLER DRIVES

17.13.1 General.

17.13.1.1 If the space, where an electrical machine and other equipment are located, is inaccessible during operation and associated with special environmental conditions (high temperature, humidity, etc.), special measures shall be taken like use of highly reliable materials and components, adequate number of sensors, as well as special means for protection of components against flooding and damages.

17.13.1.2 The components, e.g. controls, sensors, slip rings, cable connections and auxiliary drives shall withstand undamaged the strength of vibration, of at least 4g from 3 to 100 Hz.

17.13.2 Sensors.

17.13.2.1 Sensors which can be changed only during dry docking shall be fitted with two sensor elements in the same housing with separate data transmission channels.

17.13.3 Bearings.

17.13.3.1 Oil filling levels in bearing housings shall be monitored during operation and standstill. Any oil leakage shall activate an alarm. This applies to circulated lubrication systems as well.

These systems shall additionally be equipped with lubricating oil flow monitoring. A flow level monitoring alarm shall be independent from the electric propulsion motor control system.

17.13.3.2 The temperature of shaft bearings shall be monitored by an alarm and protection system. The alarm shall be carried out in two steps: alarm and engine stop.

The protection system shall be independent from the temperature indication system for shaft bearings, and the alarm system.

17.13.4 Bilges in a pod housing.

17.13.4.1 The water level in pod bilges and associated spaces shall be monitored with level sensors. In addition to high level sensors in bilges operating for an alarm system, independent sensors to monitor a high emergency level shall be provided which prevent false operations and automatically stop the propulsion.

17.13.5 Fire detection system. An effective fire detection system with the adequate number of sensors of the relevant type shall be provided. The general requirements for such systems are specified in 7.5.

17.13.6 Accessible spaces (in a pod housing). Sufficient illumination and ventilation shall be provided for accessible spaces of the pod housing where regular maintenance work and equipment inspection are carried out.

17.13.7 Protection of the propulsion motor.

17.13.7.1 Motors of more than 1 MW and all permanent excited motors shall be provided with protection against internal faults that also monitors the connections between the semiconductor converter and the motor. The power supply to the defective equipment shall be interrupted with an appropriate time delay and an alarm shall be given.

17.13.7.2 Humidity shall be monitored for motors with closed air cooling systems. The excess of the permissible humidity level shall be alarmed.

17.13.8 Motor supply lines.

17.13.8.1 Cables operated at high temperature limits shall be installed separate from other cables. If required, splitters shall be provided to prevent contacts between cable sheaths.

17.13.8.2 IP protection for all terminals, cable glands and busbar connections shall be equal to motor protection, however, at least IP44. These requirements also apply to control cables.

17.13.9 Slip rings.

17.13.9.1 Where data from feedback sensors, controlled variable sensors, etc. are transmitted via a data bus of slip rings, the busbar shall be duplicated. Failure of each single busbar shall be alarmed.

17.13.9.2 Slip rings unit fitted with external forced cooling system shall be capable of operation without a cooling system for a certain period of time. The cooling system failure shall be alarmed.

17.13.10 Azimuth podded drive and Azimuth steerable propeller drive.

17.13.10.1 Azimuth drive shall meet the requirements for steering gear in accordance with the requirements of **5.5**.

17.13.10.2 The single failure localization principle shall be ensured for all electrical and hydraulic components. Safe operation of the ship shall be ensured independently of the rudder angle and ship's speed at any time a failure occurs.

The designer shall develop and submit for approval the "Failure Mode and Effects Analysis" (FMEA).

17.13.10.3 The position of the azimuth drive shall be mechanically indicated on a scale at the drive location (steering compartment).

17.13.10.4 At least two independent electric drives shall be provided for each azimuthal unit for turn, whereby one drive shall be supplied from the main switchboard and the other, from the emergency switchboard.

17.13.10.5 Azimuth electric drives shall be protected against overcurrent (by converter, if applicable) and short circuit.

Azimuth electric drives shall be protected against overcurrent (by converter, if applicable) and short circuit. They shall be able to supply 160 % of the torque necessary for the rated speed of movement in accordance with the requirements of **7.2.3**, Part VII "Machinery Installations".

Azimuth drives with different design, e.g. hydraulic, shall also be able to fulfill the above requirements.

17.13.10.6 The thrust azimuth angle shall be limited to ± 35°.

At low propulsion power rating and thus low ship's speed or crash-stop maneuver these limits may be disabled with the control system.

17.13.10.7 The thrust azimuth angle shall be limited related to the steps of the set ship's speed that the safety of the ship is not endangered (due to excessive thrust while turning).

The limitation (interlock) shall be provided redundantly and independently of the control of the azimuth angle (pod turning).

17.13.10.8 Reaching or exceeding the permissible limitations of the azimuth angle shall be alarmed. After triggering the limitation, it shall be possible to move the azimuth drive back to the permitted angles of the drive turn without manual reset.

17.13.10.9 The operation and indication equipment of the azimuth drive shall be arranged in such a way that the set direction of the propeller thrust or the direction of the ship's moving is clearly indicated. It shall be clear to the operator whether the direction of the ship's moving or the direction of the propeller thrust of the electric propulsion plant was chosen.

17.13.10.10 The local control station for azimuthal unit shall be equipped with the following:

.1 ammeters for each supply system of each load component;

.2 azimuth angle (turn angle) indicators for each drive;

.3 power supply system readiness for operation indicators for each drive;

.4 power supply system disturbance indicators for each drive; and provide for the following:

.5 power limitation (from converter);

.6 control from main machinery control room;

.7 control from the navigation bridge;

.8 control from local control station;

.9 running indication for the associated propulsion drive.

The local control station can be activated locally at any time and shall have the highest priority.

17.14 ELECTRIC PROPULSION PLANTS CONTROL SYSTEMS

17.14.1 Powerplant control systems.

17.14.1.1 For power supply systems of electric propulsion plants with generators operating in parallel, the automated powerplant control system shall be provided which will ensure adequate power generation being consistent with the needs of specific operational modes of the electric propulsion plant, in transit/maneuver including.

Automatic load based disconnection of generators in maneuver mode is not permitted.

17.14.1.2 In case of under-frequency on main switchboard busbars, overcurrent or overload and reverse power, the propulsion power shall be automaticaly limited (to prevent de-energizing of main switchboard busbars).

17.14.1.3 If generators are running in parallel and one of them is tripping by protection system, the automated power plant control system shall automatically reduce the electric propulsion plant load to protect the remaining generators against unacceptable overloads and ensure their operation at permissible loads. The same requirement applies to the main switchboard busbars tiebreakers.

17.14.1.4 Tripping of the main switchboard busbars tiebreaker shall not lead to any malfunction of the system. It is not necessary that the power plant control system remains in the automatic mode if the power supply system is split. Any loss of the control system automatic functions shall be alarmed.

17.14.1.5 Electric power plant control system shall ensure transfer of information to electric propulsion system as regards the current value of active capacity consumption from generators to restrict the power recuperated to the unified electric power system and determination of on threshold of "braking resistors".

17.14.1.6 Electric power plant control system shall ensure transfer of information to electric propulsion system as regards the current value of reactive capacity consumption being generated by the power consumers of the unified electric power plant.

17.14.2 Location of the electric propulsion plant control stations.

17.14.2.1 Electric propulsion plant control stations may be located at any convenient place according to the ship's purpose.

Where control stations are arranged outside the machinery space, i.e. on the bridge or in other locations, control stations in the machinery space or main machinery control room shall be provided as well.

17.14.2.2 The local control station has a priority and shall be located in the vicinity of the drive or semiconductor converters. Changes of electric propulsion plant modes generated at this station shall be displayed by the system indicating a preset and executed commands.

17.14.2.3 Where several control stations are available, a control stations switch in the control station having a priority shall be provided. Such switch shall provide switching of any, but only one control station (central and wing stations on the navigation bridge are considered as one control station).

17.14.2.4 Each control station shall have an emergency stop device independent of the control system and the active (in "on" condition) control station.

17.14.3 Main and local control stations.

17.14.3.1 At least two mutually independent main and local control stations shall be provided for electric propulsion plant.

17.14.3.2 In case of damage, malfunctioning or loss of power supply of the main station control system, a local control station of the electric propulsion plant converters shall be provided.

17.14.3.3 The bridge shall be fitted with control systems such that the steering (azimuth thrust change) control system can operate independently of the speed and electric propulsion plant electric propulsion motor reverse control system.

17.14.3.4 All electric propulsion plant alarms shall be acknowledged at the local control station.

Alarms which do not require any further intervention of the personnel can be acknowledged at the main control station (on the navigation bridge) with the mandatory follow-up acknowledgement at the local control station.

17.14.3.5 Restart of the electric propulsion plant shall be possible from both (main and local) control stations, depending on which one has been preselected.

After the main switchboard de-energizing it shall be possible to restart the electric propulsion plant at the main control station.

17.14.3.6 If the electric propulsion plant is controlled from a panel or desk with the use of electric, pneumatic or hydraulic drive, the failure of them shall not result in electric propulsion plant tripping, and each control station at the panel or desk shall be immediately ready for manual operation.

17.14.3.7 Mechanically linked control stations installed in the wheelhouse (on the navigation bridge) for their synchronous operation may be permitted.

17.14.3.8 The remote control system of the electric propulsion plant shall be so designed that no time delay is needed for the personnel to move a control handle at a control station to a new position.

17.14.3.9 The electric propulsion plant control system shall be provided with an interlock to prevent the electric propulsion plant activation with a shaft turning gear engaged.

17.14.3.10 Each control station shall have a visual indication on the control system being alive.

17.14.4 Measuring, indicating and monitoring equipment.

17.14.4.1 Failures in measuring, monitoring and indicating equipment shall not result in failure of the electric propulsion plant control system, e.g. failure of the actual value (speed) sensor or of the reference speed value sensor shall not cause an excessive increase of propeller speed.

17.14.4.2 The local (active) control station shall be equipped with the following:

.1 ammeter for each power supply line of each load component (stator current of each winding, etc.), and also in the excitation circuit (for adjustible-excitation systems);

.2 voltmeters for each power supply line of each load component, and also for power supply of the excitation system (for adjustible-excitation systems);

.3 speed indicator for each shaft;

.4 "Powerplant ready for electric propulsion plant operation" indicator;

.5 "Powerplant disturbed" indicator;

.6 "Electric propulsion plant power limited" (from converter) indicator;

.7 "Control from the main machinery control room" indicator;

.8 "Control from the navigation bridge" indicator;

.9 "Control from the local control station" indicator.

17.14.4.3 The main control station (on navigation bridge) shall be equipped with the following:

.1 revolution indicator for each shaft;

.2 each shaft power meter;

.3 "Powerplant ready for switching on" (additional generators) indicator;

.4 "Power plant ready for electric propulsion plant operation" indicator;

.5 "Power plant disturbed" indicator;

.6 "Electric propulsion plant power limited" indicator;

.7 "Request to reduce power" indicator - if not automatically controlled or "override" button pushed (cancellation of the plant automated control);

.8 "Control from the main machinery control room" indicator;

.9 "Control from the navigation bridge" indicator;

.10 "Control from the local control station" indicator;

.11 indication of the generators operating at the electric propulsion plant;

.12 indication of power reserve (recommended).

17.14.4.4 When two or more control stations are provided for change of speed and angle of turn of CPP blades, both speed change and angle of turn of CPP blades indicators shall be provided at each control station.

17.14.4.5 The main machinery control room shall be equipped with the following:

.1 speed indicator for each shaft;

.2 each shaft power meter;

.3 "Powerplant ready for switching on" (additional generators) indicator;

.4 "Power plant ready for electric propulsion plant operation" indicator;

.5 "Power plant disturbed" indicator;

.6 "Electric propulsion plant power limited" indicator;

.7 "Request to reduce power" indicator - if not automatically controlled or "override" button pushed (cancellation of the plant automated control);

.8 "Control from the main machinery control room" indicator;

.9 "Control from the local control station" indicator;

.10 "Control from the navigation bridge" indicator;

.11 indication of the generators operating at the electric propulsion plant.

The list of parameters controlled by the alarm system is given in Tables **17.14.4.5-1** and **17.14.4.5-2**.

17.14.5 Fail-safety of electric propulsion plant control systems.

17.14.5.1 Electric propulsion plant control systems with the use of processors shall comply with the requirements of Section **7**, Part XV "Automation".

Таблиця 17.14.4.5-1 **List of monitored parameters of the electric propulsion plant with AC synchronous, permanent excited and induction electric propulsion motors.**

Monitored parameter	**Limiting value, Max/Min**	**Local measuring instrument**	**Alarm, display in the main machinery control room**	**Load reduction**	**Automatic "Stop"**	**Main control station (bridge), group alarm[1]**
1	**2**	**3**	**4**	**5**	**6**	**7**
Electric propulsion motor:						
Lubrication system	Malfunction	Inspection glass	X	X	X	X
Bearing temperature	Max	Thermometer	X			X
Stator winding temperature	Max		X	X		X
Slip rings (synchronous electric propulsion motor)	Malfunction ((electric arc)	Inspection hatch	X			X
Water/air cooling system	Malfunction		X			X
Cooling air temperature at the inlet	Max	Thermometer	X			X
Coolant	Leakage		X			X
Speed	Max		X		X	X

Voltage regulation (synchronous electric propulsion motor)	Failure		X		X	X
Insulation resistance for stator and feeder	Min		X			X
Insulation resistance for excitation system and feeder (synchronous electric propulsion motor)	Min		X			X
Transformers:						
Winding temperature	Max		X	X		X
Coolant	Leakage		X			X
Cooling system	Malfunction		X			X
Converters:						
Mains	Malfunction		X		Start	X
Cooling system	Malfunction		X	X		X
Power units temperature	Max		X Max1		X Max2	X
Cooling agent flow	Min		X			X
Coolant	Leakage		X			X
Preliminary alarm						X
Accident, failure			X		X	X
Rotor speed and position sensor (synchronous electric propulsion motor)	Malfunction		X			X
Emergency stop (Converter switched off)			X		X	X
Semiconductor fuse	Malfunction		X		X	X
Semiconductor temperature	Max		X	Reduction		X
Voltage (direct current link)	Max		X		X	X
Current (direct current link)	Max		X		X	X
Current at the converter outlet	Max		X		X	X
Electric propulsion plant main, shipboard electrical system:						
Harmonic trap	Accident, damage		X			X
[1] General alarm						

17.14.5.2 The loss of power or malfunctioning of any other control and monitoring systems shall not result in loss of propulsion and electric propulsion plant control, ship's steering or azimuth drive.

17.14.5.3 Electric propulsion plant, azimuth drives and their control systems shall have self-check system and an alarm system to detect failures quickly.

17.14.5.4 The most probable failures, e.g. loss of power, wire failure or cable and wire short circuits, etc. shall result in the least critical of all possible new conditions of the ship (fail to safety).

17.14.6 Power supply of electric propulsion plant control systems.

17.14.6.1 Power supply of the remote control system of electric propulsion plant shall be carried out in accordance with **3.1.2**, Part XV "Automation".

17.14.6.2 Arrangements (units) of control or controllers of each electric propulsion motor or semiconductor frequency converter shall be supplied by separate circuits. Malfunction in the supply circuit of one of such control units shall not cause loss of power supply to the remaining operative units.

Table 17.14.4.5-2 **List of monitored parameters of the electric propulsion plant with d.c. electric propulsion motors**

Monitored parameter	**Limiting value, max/min**	**Local measuring instrument**	**Alarm, display in the main machinery control room**	**Load reduction**	**Automatic "Stop"**	**Main control station (bridge), group alarm [1]**
1	**2**	**3**	**4**	**5**	**6**	**7**
Electric propulsion motor:						
Lubrication system	Malfunction	Inspection glass	X	X	X	X
Bearing temperature	Max	Thermometer	X			X
Main pole temperature	Max		X	X		X
Auxiliary pole/compensating winding temperature	Max		X	X		X
Water/air cooling system	Malfunction		X			X
Cooling air temperature at the inlet	Max	Thermometer	X			X
Coolant	Leakage		X			X
Speed	Max		X		X	X
Commutator/brushes	Malfunction (electric arc)	Inspection hatch	X			X
Armature current	Max		X		X	X
Insulation resistance for armature circuit and feeder	Min (earth fault)		X			X
Transformers:						
Winding temperature	Max		X	X		X
Coolant	Leakage		X			X
Cooling system	Malfunction		X			X
Converters:						
Mains	Malfunction		X		Restart	X
Cooling system	Malfunction		X	X		X
Power units temperature	Max		X Max 1		X Max 2	X
Cooling agent flow (direct cooling)	Min		X			X
Coolant	Leakage		X			X
Preliminary alarm						X
Accident, failure			X		X	X
Armature speed sensor	Malfunction		X			X
Emergency stop (Converter switched off)			X		X	X
Semiconductor fuse	Malfunction		X		X	X
Electric propulsion plant main, shipboard electrical system:						
Harmonic trap	Accident, damage		X			X

[1] General alarm

17.15 ELECTRIC COUPLINGS

17.15.1 General.

17.15.1.1 Electric couplings shall be designed so that they may be dismantled without the disassembly of a driving motor or reduction gear.

The design and location of couplings shall ensure free access for their maintenance, brush replacement and air gap measurements without dismantling the couplings.

17.15.1.2 Enclosures and end shields shall be made of steel or material of equivalent strength (refer also to **10.1.1**).

17.15.1.3 The rotating parts of couplings, as well as their windings shall be designed and secured so that they cannot be damaged in the event of a sudden stop. Electric couplings shall not cause axial forces. Balance ratio of electric couplings shall meet the requirements of **4.1.2**, Part IX "Machinery".

17.15.1.4 The maximum torque under excitation forcing conditions shall not exceed the twofold rated torque of the coupling. The requirements of this Chapter also apply to electric couplings fitted in other systems.

17.15.2 Protection and interlocking.

The design of the coupling connection system or the interlock used shall be such that the coupling excitation during the main propulsion engine starting and reversing is prevented.

Where several driving motors operate on a common transmission, in order to prevent the simultaneous start of driving motors rotating in opposite directions, the interlock in the coupling excitation system shall be used.

17.15.3 Electric couplings excitation.

Excitation windings of electric couplings shall be protected against overvoltage.

The excitation circuit of electric couplings shall include:

.1 a two-pole switch;

.2 a magnetic field discharging device;

.3 short-circuit protection.

18. ADDITIONAL REQUIREMENTS FOR ELECTRICAL EQUIPMENT DESIGNED FOR A VOLTAGE IN EXCESS OF 1000 V UP TO 15 KV

18.1 GENERAL

18.1.1 The requirements apply to three-phase a.c. systems with the rated voltage in excess of 1 kV where the rated voltage means the voltage between phases.

Unless otherwise specified in this Section, the requirements for design and installation for low-voltage equipment (up to 1000 V) given in this Part also apply to high-voltage equipment.

18.1.2 Electrical equipment for a voltage over 1000 V shall not be housed in the same casing (enclosure) with low-voltage equipment unless the relevant segregation is provided or appropriate measures ensuring safe access for low-voltage equipment maintenance are taken.

18.1.3 Insulating materials used for electrical equipment shall ensure the insulation resistance of 1500 ohms per 1 V rated voltage, but at least 2 megohms during the unit operation.

18.1.4 For monitoring of insulation status the systems for each feeder insulation monitoring shall be used.

Such systems shall show direction to the damaged area and have visible and audible alarm at decreasing of the monitored value below the specified level. It is recommended to complete feeder monitoring systems with portable devices for search of insulation fault location.

18.1.5 At the entrance to special electrical spaces, a warning notice shall be provided indicating the voltage. Enclosures of electrical equipment installed outside special electrical spaces shall be provided with warning notices indicating the voltage.

18.2 SYSTEM DESIGN

18.2.1 Distribution design.

18.2.1.1 The following power distribution systems may be used for three-phase a.c. current highvoltage plants:

insulated three-wire system;

three-wire system with the neutral earthed to the ship's hull through a high-capacity resistor or reactor;

four-wire system with the deadly earthed neutral.

18.2.1.2 Configuration of network for ensuring uninterruptible power supply. The main switchboard design shall provide for the possibility of its separation into, as a minimum, two independent parts by means of a circuit breaker or disconnector.

Each part of sections shall be connected to, as a minimum, one generator. Where two independent main switchboards interconnected by cable jumpers are provided, circuit breakers shall be fitted at its both sides.

All the duplicated electrical drives shall be supplied from different main switchboards or its split sections.

18.2.1.3 Systems with earthed neutral.

18.2.1.3.1 Neutral points of generators running in parallel may be connected to a common bus before an earthing resistor or reactor fitted in a switchboard or immediately at the generators.

18.2.1.3.2 In case of an earth fault, the leakage current shall not exceed the rated current of the largest generator or the total rated current of a relevant main switchboard section and shall not be less than the triple minimum current required for earth-fault protection activation.

18.2.1.3.3 When the system is energized, at least one neutral earthing point shall be closed.

The electrical equipment in systems with a deadly earthed neutral connected to the hull through a high capacity resistor or reactor shall bear without damage the single plase-to-earth fault current during the time needed for protection device activation.

18.2.1.4 Neutral opening. In the neutral wire of each generator, provision shall be made for a disconnector, which may cut out the neutral from earthing for insulation resistance measurements and generator maintenance.

18.2.1.5.1 All earthing impedances of neutral points shall be connected to the hull. The connection to the hull shall be so arranged that any circulating currents in the earth connections do not interfere with radio, radar, intercommunication and control equipment circuits.

18.2.1.5.2 It is allowed to connect all resistors or reactors to the common earthing busbar, which shall be connected to the ship's hull at least at two points.

18.2.1.6 Divided systems.

18.2.1.6.1 Neutral connections to the hull shall be provided for each split group of main switchboard sections in divided systems with an earthed neutral.

18.2.2 Degrees of enclosures protection.

18.2.2.1 General requirements.

Each part of electrical equipment shall have shielded enclosures corresponding to its location and effecting environmental conditions.

The requirements of IEC 60092-201 may be considered as minimum.

18.2.2.2 Electrical machines. A degree of protection by enclosure for electrical machines shall be at least IP23.

The degree of protection of machines lead boxes shall not be less than IP44.

Motors installed in spaces accessible to unqualified personnel shall have the degree of protection of at least IP4X to prevent touching of live and rotating parts.

18.2.2.3 Transformers.

A degree of protection by enclosure for transformers shall be at least IP23.

Transformers installed in spaces accessible to unqualified personnel shall have the degree of protection of at least IP4X.

The requirements of **18.7.1** apply to transformers having no enclosure.

18.2.2.4 Switchgear, control panels and converters.

A degree of metal enclosures protection for switchgear, control panels, static converter cabinets shall be at least IP32.

Panels installed in spaces accessible to unqualified personnel shall have the degree of protection of at least IP4X.

18.2.3 Insulation distances.

18.2.3.1 Air clearances. Air clearances between live parts with different potentials or between live parts and earthed metal parts or the casing shall not be less than specified in Table **18.2.3.1**.

Minimum clearances for intermediate values of working voltages are assumed as for the next larger value of a standard voltage.

Selecting lesser clearance, special high-voltage impulse tests shall be made to confirm admissibility of such an option.

Table 18.2.3.1

Nominal voltage, kV	**Minimum air clearance, mm**
3(3,3)	55
6(6,6)	75
10(11)	120
15	160

18.2.3.2 Creepage distances.

Creepage distances between live parts with different potentials and between live parts and the hull shall be selected on the basis of national and international standards with due regard to the rated voltage of the system, insulation material and dynamic overvoltage due to transient processes.

For non-standardized parts of equipment, including busbar sections in switchgear, the minimum surface distances should be calculated from the ratio of 25mm per 1 kV, and behind current limiting devices - 16 mm per 1 kV.

18.2.4 Protective devices.

18.2.4.1 Faults on the generator side.

In addition to the types of protection specified in **8.2**, generators shall be provided with protection devices against an interphase fault in the cables connecting the generator and main switchboard, and against turn-to-turn faults inside the generator.

When this protection device is activated, the generator shall be shut off from the main switchboard and its excitations shall automatically be removed.

In distribution systems with deadly earthed neutral, the earth fault of a generator phase shall also result in the activation of protection.

18.2.4.2 Faults to earth.

18.2.4.2.1 An audible and visual alarm shall be activated in a system at any earth faults.

18.2.4.2.2 Protection automatically disconnecting a faulted circuit at earth faults shall be activated in low-impedance (deadly-earthed) systems.

18.2.4.2.3 In high-impedance earthed systems (systems with a neutral earthed through a highresistance resistor), where the feeders outgoing from the main switchboard can not be disconnected at an earth fault, the insulation of electrical equipment supplied from these feeders shall be designed for the line voltage of the system.

18.2.4.3 Power transformers.

Power transformers shall be protected against a short circuit and overloading with circuit breakers.

Where the transformers are intended for running in parallel, the activation of protection on the primary side shall cause their automatic disconnection on the secondary side as well.

18.2.4.4 Voltage transformers for control systems and instruments.

Transformers intended for supply of control circuits and instruments shall be protected against overloading and short circuits on the secondary side.

18.2.4.5 Fuses.

Protective fuses shall be used for short-circuit protection. No fuses for overload protection are allowed.

18.2.4.6 Low-voltage systems.

Low-voltage distribution systems (up to 1000 V) supplied from high-voltage transformers (systems) shall be protected against overvoltages associated with the ingress of a high voltage on the secondary (low voltage) side.

This may be achieved by:

earthing of the low voltage system;

appropriate neutral voltage limiters;

earthed screen between the primary and secondary windings of the transformer.

18.2.4.7 Protective earthing.

Metal enclosures of electrical equipment shall be earthed by external flexible copper conductors having a cross-sectional area designed for a single-phase short-circuit current, but not less than 16 mm^2 . Earthing wires shall be marked.

Earthing conductors may be connected by welding or by bolts of at least 10 mm in diameter.

18.3 ELECTRICAL MACHINES

18.3.1 Stator windings of generators.

Generator stator windings shall have accessible both phase and neutral ends to ensure the installation of the differential protection.

18.3.2 Temperature detectors.

Electrical machines shall be fitted with built-in temperature detectors in their stator windings to actuate an audible and visual alarm whenever the temperature exceeds the permissible limit. For built-in temperature detectors, means shall be provided to protect measurement circuits against overvoltage.

18.3.3 Tests.

In addition to the tests required for all electrical machines, high-frequency testing voltage tests, in accordance with IEC 60034-15, of individual phase windings (coils) of the machine shall be provided to demonstrate a satisfactory level of resistance to turn-to-turn faults caused by step-fronted switching surges.

18.3.4 Design.

18.3.4.1 A machine casing, bearing shields, guards of air intakes and outlets shall be made of steel alloys. Aluminium alloys for the above parts are not allowed.

18.3.4.2 A draining arrangement readily accessible for maintenance shall be provided in the lower part of a machine casing for removal of condensate.

Vertically-designed motors shall be fitted on their top with a rigidly secured canopy preventing the ingress of water and foreign objects inside the machine.

A lower end shield shall be shaped so as to prevent accumulation of water in way of a bearing.

18.3.4.3 Lead boxes of machines shall be dimensioned so as to ensure:

necessary insulation distances between current-carrying parts and the casing;

necessary insulation distances between phases;

a sufficient space for arrangement of connecting cable terminations and windings ends;

changing the position of the power cable entries up to four positions at an angle of 90°.

An individual terminal box shall be provided for instrument current transformers, heating anticondensation elements, temperature detectors, etc.

18.3.4.4 The leads of stator winding phases shall enter a separate terminal box, which is different from the ones for lower voltages, through a sealing gasket.

A separate terminal box may be provided for neutral leads.

Terminals for earthing cable cores shall be provided inside terminal boxes.

In this case, a reliable electrical connection between a machine casing and box body shall be ensured.

18.3.4.5 Motors having the rated power 1000 kW and over shall be fitted with differential protection devices. For this purpose, a separate lead box shall be provided on a motor casing, located on the opposite side from the main box, in which a sufficient space for three current transformers and leads of neutral winding ends shall be provided.

In case of the impossibility, due to the small size of the engine room, to mount the above-mentioned lead box on the opposite side from the main box, the said box may be mounted at any convenient place on the motor casing.

18.3.4.6 Bearings temperature of motors with power of 1000 kW and over shall be monitored by local indicators (devices).

Temperature detectors for remote control shall also be provided for each bearing.

18.3.4.7 In order to prevent the harmful effect of bearing currents, the bearing on the side opposite to a drive shall be electrically isolated from a casing.

The possibility of measuring insulation resistance of an isolated bearing without its disassembly shall be provided.

18.3.4.8 The design of plain bearings shall provide:

local indicators of the lube oil level;

separate pump with a local pipeline, tank, cooler, filter and flow-rate indicator when forced circulating lubrication is used;

potential fitting of instruments for vibration control, including pertinent cable lines, as well as of instruments for bearing wear measurements;

potential use of the motor starting interlock when lubrication fails.

18.4 POWER TRANSFORMERS

18.4.1 Загальні вимоги.

18.4.1.1 Dry-type transformers shall meet the requirements of IEC 60076-11 or the relevant EN or IEC standards.

Dry-transformers in use shall have earthed screens between high and low voltage windings.

Liquid-cooled transformers shall meet the requirements of IEC 60076 -13.

Oil-immersed transformers shall shall meet the requirements of IEC 60076-14 or the relevant EN or IEC standards and, as a minimum, be provided with the following alarms and protections:

"minimum liquid level" - alarm and automatic trip or load reduction;

"maximum liquid temperature" - alarm and automatic trip or load reduction;

"high gas pressure in enclosure" - automatic trip.

18.4.1.2 Transformers located in spaces accessible to unqualified personnel shall have a degree of protection provided by enclosure of at least IP4X.

18.4.1.3 Where the low-voltage side of transformer has an insulated neutral point, a spark fuse shall be inserted between the neutral point of each transformer and ship's hull.

The fuse shall be rated for not more than 80 % of the minimum test voltage of services fed through the given transformer.

18.4.1.4 The equipment for monitoring the condition of insulation on the lower-voltage side of the unit or for detecting locations of this insulation damages may be connected to the fuse in parallel.

This equipment shall not interfere with the reliable operation of the fuse.

18.4.1.5 Effective means (e.g. heating) shall be provided to prevent condensation and moisture accumulation inside the transformers when de-energized.

18.4.1.6 Use of aluminium as material for the transformer windings is permitted provided the following conditions are met:

.1 provision is made for protection of the windings and their outlets from the corrosion in the conditions of the open sea;

.2 provision is made for protection from galvanic corrosion at the joints of the windings with currentcarrying parts made from other materials;

.3 joints indicated in **18.4.1.6.2** are accessible for inspection and protected from loosening.

18.5 CABLES

18.5.1 General.

18.5.1.1 Cables shall be constructed in accordance with the requirements of IEC 60092-353 and 60092-354 or other equivalent standards.

18.5.1.2 For three-phase cable systems, triple-core cables with multiwire cores shall be used. The cross-sectional area of the cable conductor for power circuits shall be at least 10 mm^2.

18.6 SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

18.6.1 General.

18.6.1.1 Switchgear and controlgear assemblies shall be constructed according to IEC 62271-200 or the relevant EN or IEC standards and the following additional requirements.

18.6.2 Construction.

18.6.2.1 Mechanical construction.

18.6.2.1.1 Switchgear shall be of the metal-enclosed type in accordance with the requirements of IEC 62271-200 or the relevant EN or IEC standards or other international and national standards recognized by the Register.

18.6.2.1.2 Switchboards shall be locked with a special key other than for lower-voltage switchboards and switchgear.

Opening of doors and withdrawal of separate part shall be possible only after disconnection of the panel or switchboard from the electric network.

18.6.2.1.3 Passageways for a switchboard and electrical equipment inspection at least 800 mm wide and 1000 mm wide between the bulkhead and switchboard, and between parallel switchboard sections respectively, shall be provided along the switchboards.

Where intended for maintenance, their width shall be increased up to 1000 mm and 1200 mm respectively.

The specified width of these passageways is required irrespective of the applied means of protection against contact, like doors, a net or insulated guardrails.

The doors, continuous bulkheads and net screens shall be at least 1800 mm high.

The perforated bulkheads or net screens shall ensure a degree of protection not below IP2X.

Two insulated guardrails shall be fitted along the switchboard at the heights of 600 mm and 1200 mm.

18.6.2.1.4 Live parts of electrical installation shall be located at a distance specified in Table **18.6.2.1.4** away from protection guards.

Table 18.6.2.1.4

Nominal voltage, kV	Minimum height of passageway, mm	Minimum distances of live electrical parts from various protection guards, mm		
		solid doors and continuous	bulkheads net doors and screens	insulated guardrails
3(3,3)	2500	100	180	600
6(6,6)	2500	120	200	600
10(11)	2500	150	220	700
15	2500	160	240	800

18.6.2.2 Locking facilities.

Withdrawable circuit breakers used in switchboards shall be provided with mechanical locking facilities in both service and disconnected positions.

For maintenance purposes, key locking of withdrawable circuit breakers and other equipment and fixed disconnectors shall be provided.

Withdrawable circuit breakers shall be located in the service position so that there is no relative motion between fixed and moving portions.

18.6.2.3 Shutters.

The fixed current-carrying contacts of withdrawable circuit breakers shall be automatically covered by insulating shutters when the circuit breaker is drawn out.

Insulating shutters for incoming and outgoing circuits may be done by using colours or labels.

18.6.2.4 Earthing and interphase fault devices.

In order to ensure the safe maintenance of high-voltage switchgear, an adequate number of devices for forced busbar fault and earthing for busbars and outgoing feeders shall be provided.

The device must be designed for the maximum short-circuit current.

18.6.2.5 Internal arc classification (IAC).

Switchgears and controlgear assembles shall be classified according to internal arc classification.

Where switchgear is accessible by authorized personnel only Accessibility Type A is sufficient. Accessibility Type B is required if accessible by non-authorized personnel (refer to IEC 62271-200 or the relevant EN or IEC standards, Annex AA; AA2.2).

Installation and arrangement of the switchgear and contourgear shall comply with their IAC and arrangement (F - Front side; L - Lateral side; R - Rear side).

18.6.3 Auxiliary supply system.

18.6.3.1 Source of supply.

Where a separate auxiliary electrical or other source of power is required for operation of circuit breakers and other switches, and also for protection devices, in addition to such a main source, a stand-by one, which an energy supply shall be sufficient for at least two operations of all the components, shall be provided.

However, the circuit breaker releases activated due to overload, short-circuit or undervoltage shall be independent of any electrical sources of power.

The requirements does not preclude using the releases activated by an operating voltage, provided that the control of tripping circuits and their supply system integrity (continuity) will be ensured, i.e. if the integrity of the circuits is broken or their supply system is faulty (fails), an alarm will be activated.

18.6.3.2 Number of supply sources.

At least one independent stand-by source of power supply for split main switchboards (refer to **18.2.1.1**) for operation of circuit breakers and other switches, in addition to their own supply sources each fed from its own busbar system, shall be provided.

Where necessary, an emergency source of electrical power intended for activation of the machinery installation from fully de-energized or dead ship condition may be used for this purpose.

18.6.4 High-voltage tests.

Every main and other switchboards shall be tested by a high voltage of standard frequency. The test procedure and voltage values shall meet the requirements of an appropriate national standard or IEC 62271-200 or the relevant EN or IEC standards.

18.7 INSTALLATION

18.7.1 Electrical equipment.

18.7.1.1 Where high-voltage equipment is not contained but a special room forms the enclosure of the equipment, the access doors shall be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down.

At the entrance of the rooms or spaces where high-voltage equipment is installed, caution notes shall be placed, which indicate danger of high-voltage.

The relevant free space shall be provided in the vicinity of high-voltage equipment to prevent significant potential hazard to the service personnel during the technical maintenance.

In addition, the distance between the switchboard and the above ceiling/deck shall meet the requirements of internal arc classification in compliance with IEC 62271-200 or the relevant EN or IEC standards.

18.7.1.2 Electrical equipment shall be in special electrical spaces and shall have a degree of protection at least IP23 (refer also to **18.6**).

When justified, the equipment may be installed outside the above spaces provided its degree of protection is the last IP44 and access to current-carrying parts of the equipment will only be possible when the voltage is off and special tools are used.

18.7.1.3 A diagram of connections and a drawing of electrical equipment arrangement shall be available in the special electrical space.

18.7.2 Cables.

18.7.2.1 Cable run laying.

Cables shall not run through accommodation spaces. However, when required due to technological reasons, such laying is allowed in special enclosed transit systems (structures).

18.7.2.2 Segregation.

High-voltage cables shall be segregated from cables for voltage below 1000 V.

In particular, they shall not be run in the same cable bunch, nor in the same ducts or pipes, or in the same boxes with cables for a voltage 1000 V and below.

Where high-voltage cables of different voltage ratings are installed on the same cable tray, the insulation distances between the cables shall not be less than those specified for a high-voltage cable according to **18.2.3.1**.

18.7.2.3 Installation of cables.

High-voltage cables shall be laid in earthed metallic pipes or metallic ducts, or to be protected by earthed metallic enclosures.

Open installation of cables (on carrying pressed panels) is allowed if they have a continuous metallic armour, which shall be reliable and repeatedly earthed.

18.7.2.4 Cable terminations.

Terminations in all conductors of high-voltage cables shall be effectively covered with a suitable insulating material.

In terminal boxes, if conductors are not insulated, phases shall be separated from earth and from each other by other by durable barriers of a suitable insulating material.

High-voltage cables, having a conductive layer between phases to control the electric field within the insulation, shall have terminations, which provide electric stress control.

Terminations shall be of the type compatible with the insulation and jacket material of the cable and to be provided with means for earthing all metallic shielding components (metallic tapes, wires, etc.).

18.7.2.5 Marking.

High-voltage cables shall be readily identifiable by suitable marking.

18.7.2.6 Tests after installation.

Before putting into service of a new high – voltage cable network or after its updating (repair or additional cables installation), each cable and its accessories (terminations, earthing ends, etc.) shall be tested by a high voltage.

Tests shall be carried out after an installation resistance measurement.

For the cables of a rated voltage (U_o /U) above1,8/3kV (U_m = 3,6kV) testing of electric strength of insulation shall be performed by a.c. testing voltage in compliance with the manufacturer's recommendations as follows:

a) during 5 min by phase-to-phase voltage of the system being applied between the cable core and a metal screen/braiding;

b) during 24 h by nominal voltage of the system.

Or by the d.c voltage being equal to $4U_o$ during 15 min.

For the cables of a rated voltage (U_o /U) above1,8/3kV (U_m = 3,6kV) testing of electric strength of insulation is made by d.c. voltage equal to $4U_o$ during 15 min.

where: U_o is rated a.c. voltage of rated frequency for which the cable is intended applicable between the phase wires and earthing and a metal screen;

U is rated a.c. voltage ofrated frequency for which the cable was intended applicable between the phase wires;

U_m is maximum voltage value in the high voltage system when the equipment capable for operation.

Upon testing, the cable cores shall be grounded for the certain period of time sufficient for removal of the obtained electric charge.

Then the repeated measurement of cable insulation resistance shall be made.

19. REQUIREMENTS FOR ELECTRICAL EQUIPMENT PROCEEDING FROM SHIP PURPOSE

These requirements shall be considered as amendments or additions to the relevant requirements specified in **1-18** of this Part of the Rules.

19.1 PASSENGER SHIPS

19.1.1 Supply and signalling.

19.1.1.1 Electric drives of sea-water pumps, air compressors and control-and-signalling devices of automatic sprinkler systems shall be supplied directly from the main and the emergency distribution boards through separate feeders.

The feeders shall be connected to an automatic switch fitted near the pump of the sprinkler system. Normally, the switch shall be connected to the feeder from the main distribution board, and in case of supply failure it shall automatically switch over to the supply feeder from the emergency distribution board.

At the main and the emergency distribution boards, the switches of the feeders shall be clearly marked off and shall be permanently in the "on" position. No other switches shall be fitted to these feeders.

19.1.1.2 Supply cables of sea-water pumps, air compressors and control-and-signalling devices of automatic sprinkler systems shall not run through machinery casings, galleys and other enclosed spaces of high fire hazard, except where the above devices and machinery are installed in the spaces in question.

19.1.1.3 In saloons, in way of stairs, passages and ladders to the boat deck, the lighting fixtures shall be supplied through two independent feeders at least (refer also to **6.2.3**).

19.1.1.4 The supply systems of essential ship gear shall be so designed that a fire in one of the main vertical fire zone would not damage the above service supply systems in another main vertical fire zone.

This requirements may be considered satisfied where the main and emergency supply feeders of the services running through any such zone are as distant from each other as possible both vertically and horizontally.

19.1.1.5 General alarm system shall consist of two independent groups: one for passengers and the other for the crew.

A special alarm, operated from the navigation bridge or fire control station, shall be fitted to summon the crew.

The alarm may be part of the ship's general alarm system the requirements for which are specified in 7.4.

In passenger ships with a low-power electrical plant or with a number of passengers less than 36, one group of general alarms is permitted.

19.1.1.6 A fixed fire detection and fire alarm system shall meet the following requirements (additional to **7.5**):

.1 be capable of remotely and individually identifying each detector and manually operated call point;

.2 one section of automatic and manual detectors shall not be located in more than one main vertical zone;

.3 when the system is required to sound a local audible alarm within the cabins where the detectors are located, means to silence the local audible alarms from the control panel shall not be permitted**.**

19.1.2 Supply from emergency sources of electrical power.

19.1.2.1 In passenger ships of unrestricted service and of restricted area of navigation **R1** and with signs **A**, **A-R1**, the emergency sources of electrical power shall simultaneously supply, during 36 h, the following services:

.1 emergency lighting for: muster and embarkation stations for boarding life-saving appliances and spaces overboard where lifesaving appliances are launched according to **2.3.4** and **2.7.7**, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships;

indicators of exits to the boat deck and notice-plates at the life-saving appliances;

exits from the spaces where a large number of passengers, special personnel or crew members can gather simultaneously;

alleyways, stairways and exits to the open deck in all accommodation and service spaces as well as passenger lift cars;

machinery spaces and generator rooms with their local control stations;

all control stations as well as main and emergency switchboards;

emergency diesel generator space;

wheelhouse;

chartroom and radioroom;

stowage positions for emergency and fireman's outfit and positions where manual fire alarms are fitted;

steering gear compartments;

positions of attendance upon emergency fire and bilge pump, sprinkler pump and starting positions of their motors;

helicopter hangars and landing areas;

gyrocompass space;

medical space;

.2 navigation lanterns, lanterns of "Vessel not under command" signal and other lanterns required by Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships;

.3 radio equipment and navigational equipment according to the requirements of Parts IV "Radio Equipment" and V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships;

.4 internal communication, announcing and general alarm systems;

.5 fire detection and alarm systems, fire door control devices and indicators showing the position of fire doors specified in **2.2.3.3**, Part VI "Fire Protection";

.6 sound signal means (whistle, gong, etc.), daylight signalling lamps, manual summoning signals and other signals as required under emergency conditions;

.7 one of the fire pumps, a pump of the automatic sprinkler system, an electric-driven pump of the pressure water-spraying system referred to in **3.4.7**, Part VI "Fire Protection", as well as electrical equipment used to ensure operation of the high expansion foam fire extinguishing systems referred to in **3.7.3**, Part VI "Fire Protection";

.8 emergency bilge pump and equipment essential for operation of remote-controlled bilge valves;

.9 services listed in **7.3.6** and **7.3.8**, Part VI "Fire Protection" for Class **INF2** and **INF3** ships in accordance with classification given in **7.3.2**, Part VI "Fire Protection", regardless of area of navigation and tonnage of the ship;

.10 other systems, which operation will be considered by the Register to be vital for ensuring the safety of the ship and persons on board.

The services indicated in **19.1.2.1.3** to **19.1.2.1.6** may be fed from its own accumulator batteries located according to **9.2** and having a capacity sufficient for their supply for a period of 36 h.

For ships of restricted areas of navigation not specified above (refer to **19.1.2.1**), the period of 36 h may be reduced to 12 h.

19.1.2.2 Emergency sources of electrical power shall ensure the supply of steering gear in accordance with **5.5.6**.

19.1.2.3 Emergency sources of electrical power shall supply, for a period of 30 min, the following services:

.1 electrical drives of watertight doors together with their indicators and warning signals. Sequential operation of the doors may be permitted providing all doors can be closed in 60 s;

.2 emergency electric drives of passenger lifts. Passenger lifts may be operated sequentially;

.3 supplementary lighting shall be provided in all cabins to clearly indicate the exit. Such lighting may be connected to an emergency source of power or have a self-contained source of electrical power in each cabin.

19.1.2.4 Where a generator serves as the emergency source of electrical power, it shall be:

.1 driven by an internal combustion engine (refer to **2.2.5**, Part IX "Machinery");

.2 automatically started in case of supply failure, and automatically switched over to the busbars of the emergency distribution board; services listed under **19.1.2.7** shall be automatically supplied from the emergency generator.

The total time for starting and carrying the board by the generator shall not exceed 45 s;

.3 for an emergency, a transitional source of electrical power shall be provided, which shall be activated immediately upon de-energizing.

19.1.2.5 Where an accumulator battery serves as the emergency source of electrical power, it shall:

.1 operate without recharging and with voltage across its terminals within 12 % of rated voltage during the whole discharge period, where voltage variations across the terminals of accumulator battery connected to an electronic voltage converter are determined by the permissible range of voltage variation across the terminals of the converter;

.2 be automatically connected to the busbars of the emergency distribution board in case of supply failure and supply at least the services listed under **19.1.2.7** during the time stipulated by **19.1.2.1**.

19.1.2.6 For the emergency transitional source of electrical power required by **19.1.2.4.3**, an accumulator battery shall be used, which shall operate without recharging and with voltage across its terminals within 12 % of rated voltage during the whole discharge period.

Voltage variations across the terminals of accumulator battery connected to an electronic voltage converter are determined by the permissible range of voltage variation across the terminals of the converter, which shall not be above values specified in **2.1.3.1**.

19.1.2.7 The capacity of the battery serving as transitional source of electrical power shall be sufficient for supplying the services listed below during 30 min:

.1 lighting and necessary navigation lights according to **19.1.2.1.1** and **19.1.2.1.2**;

.2 internal communication and announcing systems required in an emergency;

.3 general alarm system, fire detection and alarm systems, control devices of fire doors and indicators showing the position of fire doors specified in **2.2.3.3**, Part VI "Fire Protection";

.4 daylight signalling lamps, sound signal means (whistles, gongs, etc.) and other types of signals required under emergency conditions;

.5 arrangements for closing watertight doors, their position indicators and signals warning of their closing. Sequential closing is permitted;

.6 ship's security alarm system and AIS installation required by Part IV "Radio Equipment" and Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

Services listed under **19.1.2.7.2** to **19.1.2.7.6** may be supplied from their own accumulator batteries, which shall ensure their supply during the time necessary.

19.1.3 Electrically powered low-location lighting (refer to 8.5.5, Part III "Equipment, Arrangements and Outfit").

19.1.3.1 The low-location lighting system shall be connected to the busbars of the emergency switchboard so as to be powered by the main source of electrical power under normal circumstances and also by the emergency source of electrical power when the latter is in operation.

The low-location lighting system shall function at all times**.**

19.1.3.2 Where an accumulator battery is the emergency source of electrical power, its capacity shall be sufficient for powering the low-location lighting system for at least 60 min.

19.1.3.3 The additional emergency lighting required by 19.3.3 may be accepted to form partly or wholly the low-location lighting system, provided that such system complies with the requirements of **19.1.3**.

19.1.3.4 The electrically powered low-location lighting system shall ensure the following minimum standards of luminance:

.1 for luminous surface of the planar source - 10 cd/m^2, the light band being not less than 15 mm in width;

.2 for the point source - 35 mcd in the directions of approach and viewing, along with that: the direction of viewing for the sources located on a horizontal plane, i.e. on the deck, shall be within a cone with an angle of 60°, the axis of which is inclined at 30° to the source installation plane (refer to Fig. 19.1.3.4.2-1);

the direction of viewing for the sources located on a vertical plane, i.e. on the bulkheads (e.g. for marking of the door handles) shall be within a cone with an angle of 60°, the axis of which is perpendicular to the source installation plane (refer to Fig. 19.1.3.4.2-2);

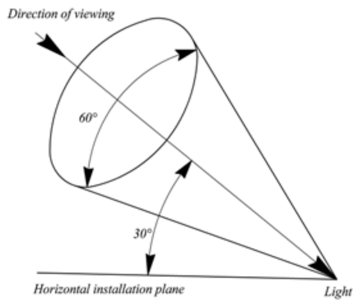


Fig.19.1.3.4.2-1

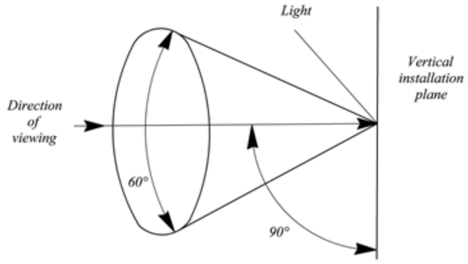


Fig.19.1.3.4.2-2

spacing between sources shall be not more than 300 mm.

19.1.3.5 Power supply of the LLL system shall be such that a failure of any single light or fire in one fire zone or on one deck do not result in lighting and escape route marking in another fire zone being ineffective.

19.1.3.6 Failure or damage, other than short circuit, of any single light, shall not result in loss of visible delineation of the escape route at a length of more than 1 m.

19.1.3.7 The electrical equipment (lights) shall be provided with a minimum degree of ingress protection of IP55**.**

19.1.4 Additional requirements for passenger ships having a safety centre.

19.1.4.1 Internal communication shall comply with the requirements of **2.2.8.3** and **2.2.8.5**, Part VI "Fire Protection".

19.1.4.2 General alarm shall comply with the requirements of **2.2.8.6.4**, Part VI "Fire Protection".

19.1.4.3 Indication of closing watertight and fire doors shall comply with the requirements of **2.2.8.6.3**, Part VI "Fire Protection".

19.1.4.4 Flooding detection system shall comply with the requirements of **2.2.8.6.8**, Part VI "Fire Protection".

19.1.4.5 Indication of closing doors on passenger ro-ro ships shall meet the requirements of **2.2.8.6.7**, Part VI "Fire Protection".

19.1.5 Additional requirements for passenger ships having length, as defined in 1.2.1 of the Load Line Rules for Sea-Going Ships, of 120 m or more or having three of more main vertical zones.

19.1.5.1 Steering systems and steering-control systems shall comply with the requirements of **2.2.6.7.2** and **2.2.6.8**, Part VI "Fire Protection".

19.1.5.2 Lighting of safety areas shall comply with the requirements of **2.2.6.13.7**, Part VI "Fire Protection".

19.1.5.3 Lighting along escape routes, at assembly stations and at embarkation stations of life-saving appliances, shall comply with the requirements of **2.2.7.4.2**, Part VI "Fire Protection".

19.1.5.4 Internal communication shall additionally comply with the requirements of **2.2.6.7.6**, **2.2.6.8** and **2.2.7.4.4**, Part VI "Fire Protection".

19.1.5.5 Flooding detection system shall comply with the requirements of **2.2.6.7.7** and **2.2.6.8**, Part VI "Fire Protection".

19.1.6 Emergency lighting shall be provided at all cabins for clear exit identification for cabin occupants.

Such lighting powered from an emergency power supply or from its own power source at each cabin shall switch on automatically in the event of loss of power by the regular cabin lighting, and shall remain on for at least 30 min**.**

19.2 OIL TANKERS AND OIL RECOVERY SHIPS

19.2.1 General.

The requirements of the Chapter cover the electrical equipment of oil tankers and oil recovery ships intended for the carriage of petroleum products having a flash point 60°C and below and petroleum products having a flash point 60°C and above, which require heating up to a temperature less than 15°C below the flash point.

The electrical equipment of oil tankers (>60°C), oil recovery ships (>60°C) and bilge water removing ships (>60°C) is covered by the requirements of **19.2.3.2.3.2**, **19.2.5**, **19.2.6.2** (refer also to **9.6.5**, Part VIII "Systems and Piping").

The requirements of this Chapter specify the boundaries of dangerous zones, the division of ship's spaces and areas into zones, the installation of electrical equipment in hazardous spaces and areas in compliance with IEC 60092-502 "Electrical Installations in Ships – Tankers – Special Features".

19.2.2 Distribution of electrical power.

19.2.2.1 For distribution of electrical power on board the ship, only the following systems may be used:

.1 two-wire insulated system for direct current;

.2 two-wire insulated system for single-phase alternating current;

.3 three-wire insulated system for three-phase alternating current (also for voltage above 1000 but not in excess of 11000 V a.c.);

.4 three-wire system with neutral earthed through a high-value resistor for voltages above 1000 but not in excess of 11000 V a.c., provided that any possible resulting current does not flow directly through any dangerous spaces and areas.

19.2.3 Dangerous zones, spaces and areas.

19.2.3.1 Classification of dangerous zones.

Zone 0, in which an explosive gas/air mixture is continuously present or present for long periods.

Zone 1, in which an explosive gas/air mixture is likely to occur in normal operation.

Zone 2, in which an explosive gas/air mixture is not likely to occur, and if it occurs it will only exist for a short time.

19.2.3.2 Division of spaces and areas into zones.

19.2.3.2.1 Zone 0:

.1 internal areas of cargo compartments and tanks, cargo piping and transfer systems of recovered oil;

.2 open areas lying at a height up to 1 m from oil-covered water surface (for ships operating in the oil spill).

19.2.3.2.2 Zone 1:

.1 cofferdams and segregated ballast tanks adjoining cargo tanks as well as the forepeak, if served by a system connected to ballast tanks installed in the cargo area;

.2 enclosed or semi-enclosed spaces containing cargo pumps or cargo piping, provided the latter is not all-welded;

.3 enclosed and semi-enclosed spaces above the deck of cargo compartments and tanks, which have their bulkheads above or level with the bulkheads of the cargo compartments and tanks;

.4 enclosed and semi-enclosed spaces immediately above cargo pump rooms and also above vertical cofferdams adjoining cargo compartments and tanks unless separated by a gastight deck and provided with mechanical ventilation;

.5 areas and spaces other than cofferdams adjoining cargo compartments and tanks and located below cargo compartment and tank top;

.6 areas and semi-enclosed spaces on the open deck within 3 m of any outlets otherthan ventilation outlets, cargo tank manholes and hatches, pump rooms and cofferdams adjoining cargo tanks, of cargo valves and cargo piping flanges, as well as areas on open deck within 3 m of cargo vapour outlet (small volumes) and of the pump room ventilation outlets mentioned in **9.7** and **12.4.6**, Part VIII "Systems and Piping";

.7 areas on open deck, or semi-enclosed spaces on open deck in the vicinity of any cargo gas outlet arranged according to **9.7.11**, Part VIII "Systems and Piping", equipped with high-speed devices to ensure the passage of large volumes of gas or vapour mixture at the rate of 30 m/s at least during cargo loading and ballasting or during discharging, within a vertical cylinder of unlimited height and 6 m radius centred upon the center of the outlet, and within a hemisphere of 6 m radius below the outlet;

.8 areas on open deck, or semi-enclosed spaces on open deck, within 1,5 m of cargo pump room entrances, cargo pump room ventilation inlet, openings into cofferdams or other zone 1 spaces;

.9 areas on open deck within spillage coamings and trays surrounding cargo manifold valves and 3 m beyond these, up to a height of 2,4 m above the deck;

.10 areas on the open deck above cargo compartments and tanks over the full breadth of the ship and 3 m fore and aft of their boundary bulkheads up to a height of 2,4 m above the deck as well as enclosed and semi-enclosed spaces within this area.

For ships operating in the oil spill, this area is extended to cover the whole length of the ship;

.11 storage spaces for cargo hoses and equipment for collecting spilt oil (oil collectors);

.12 enclosed and semi-enclosed spaces having direct access or other openings into one of the above areas and spaces;

.13 spaces and areas above cofferdams adjoining cargo compartments and tanks, which are not divided by oil- and gastight bulkheads and decks, not adequately ventilated and entered from an upper deck.

19.2.3.2.3 Zone 2:

.1 areas above zone 1 over the full breadth and length of the ship to a height of 6 above the deepest load waterline (for ships operating in the oil spill);

.2 internal areas of cargo compartments and tanks, slop tanks, cargo piping, transfer systems of recovered petroleum products having a flash point >60 8C and their ventilation systems;

.3 areas on open deck or semi-enclosed spaces 4 m beyond the cylinder and 4 m beyond the sphere with the radius of 6 m defined in **19.2.3.2.2.7**.

.4 areas or spaces within 2 m of the areas defined in**19.2.3.2.2.6**.

19.2.3.2.4 Spaces and areas not included in zones 0, 1 and 2 are considered safe.

19.2.3.3 Enclosed spaces having direct access to or other openings into areas listed under **19.2.3.2.2.10** are not regarded as dangerous if provision is made for two self-closing gastight doors forming an air lock and, additionally, for mechanical supply ventilation with air suction from locations outside dangerous zones.

19.2.3.4 In the case of ships operating in the oil spill, entrances, ventilation openings (both for suction and discharge) and other openings of safe spaces such as accommodation, service spaces and machinery spaces, control stations and wheelhouse, which have no gastight closures, shall not be located more than 6 m below the deepest waterline and, under all circumstances, shall be outside dangerous zones.

Entrances to safe spaces lying more than 6 m below the deepest waterline or within dangerous zones shall be provided with air locks. In such spaces, openings more than 6 m below the waterline shall bear gastight closures when operating in the oil spill.

19.2.4 Electrical equipment in hazardous areas.

19.2.4.1 Only the following electrical equipment may be considered for zone 0 spaces:

.1 certified intrinsically-safe apparatus of category (*ia*);

.2 simple electrical apparatus and components (for example, thermocouples, photocells, strain gauges, junction boxes, switching devices, included in intrinsically-safe circuits of category (*ia*), not capable of storing or generating electrical power or energy for ignition of explosive mixture even in case of disconnection, short circuit or earth fault in the intrinsically-safe circuit.

19.2.4.2 Only the following electrical equipment may be considered for zone 1 spaces:

.1 any type that may be considered for zone 0;

.2 certified intrinsically-safe apparatus of category (*ib*);

.3 simple electrical apparatus and components (for example, thermocouples, photocells, strain gauges, junction boxes, switching devices, included in intrinsically-safe circuits of category (*ib*), not capable of storing or generating electrical power or energy for ignition of explosive mixture at normal operating conditions;

.4 certified flameproof type (*d*);

.5 certified pressurized type (*p*).

In this case automatic shutdown is required when values of overpressure fall below minimum prescribed values;

.6 certified increased safety type (*e*).

In this case the electric motors with voltage of 3kV and above require an addition protection such as air purging prior to the start to reduce the risk of spark striking in the air gap;

.7 with compound sealing (*m*) ;

.8 special explosion protection (*s*);

.9 echo sounder transducers and their cables in compliance with the requirements of Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships, cables of an impressed current cathodic protection system, housed within corrosion-resistant steel pipes with gastight connections up to the upper deck and not located adjacent to a cargo tank bulkhead (refer also to **16.8.4.2**);

.10 through runs of cables.

19.2.4.3 The electric motors driving the arrangements located in pump rooms shall be installed in adjacent flameproof spaces (refer also to **4.2.**5, Part VII "Machinery Installations").

The electric motors shall be fitted with remote shut-down devices located outside the spaces where the motors are installed and above the cargo tank deck (refer also to **9.4.4**, Part VIII "Systems and Piping").

19.2.4.4 Lighting in pump rooms shall be interlocked with ventilation of these spaces in such a way as to ensure the possibility of the lighting switching on with ventilation in operation only. Failure of the ventilation system shall not result in the lighting switching off. Emergency lighting, if fitted, shall not be interlocked with ventilation.

19.2.4.5 Only the following electrical equipment may be considered for zone 2 spaces:

.1 any type that may be considered for zone 1;

.2 tested specially, for example type (*n*) protection;

.3 the type which ensures the absence of sparks and arcs and of "hot spots" during its normal operation.

19.2.5 Portable electrical equipment used for collecting spilt oil.

19.2.5.1 Portable equipment for collecting and transfer of oil shall be of safe type.

19.2.5.2 Distribution boards and socket outlets for supplying portable oil-collecting and transfer equipment on deck shall be permanently fitted in such a way that a cable connected to them would not pass through door coamings or other closed openings serving as a boundary of dangerous spaces and zones.

The design of such distribution devices and socket outlets shall provide for an interlock that would rule out the possibility of the portable electrical equipment being connected to them when energized and ensure protection from short-circuit currents and overvoltage in each phase.

19.2.5.3 Flexible cables for connection of portable electrical equipment used for collecting spilt oil shall have a metallic braid (screen) covered by an external proof sheathing of an oil-resistant material.

19.2.6 Installation of cables.

19.2.6.1 On the decks of oil tankers and oil recovery ships, cables shall run on flying bridges in suitable conduits (grooves). Single cables may be laid in pipes.

Where the flying bridges are within zone 1, cables complying with the requirements of **2.9.11** shall only be installed.

19.2.6.2 When cables are installed in conduits (grooves), the following requirements shall be met:

.1 cables in conduits (grooves) shall be loosely laid in rows on separators of non-metallic materials; in this case, the possibility of lateral displacement of the row (cable) shall be excluded.

It is permitted to use methods of fixed pipeless installation of cables (in cable hangers, under clips), which shall be approved by the Register from the viewpoint of the design features;

in case of fixed installation cables shall be laid not more than in two rows;

.2 cables shall not be in contact with metal parts of the conduit (groove);

.3 cables shall not be subjected to constant or variable tensions due to deformation of the ship's hull and shall be protected from this deformation, especially in way of detachable or sliding connections between the gangway or platform and superstructures. In way of detachable or sliding connections of the gangway or platform provision shall be made for expansion loops having the inside radius of not less than 10 diameters of the thickest cable;

.4 cables shall be protected from direct exposure to solar radiation, sea waves, oil products carried on board the ship and from mechanical damage;

.5 cables shall be separated from sources of heat by a distance specified in **16.8.4.1**;

.6 cables runs on the passageway platform or in pipes inside spaces within zone 1, as well as expansion loops shall not be located below 300 mm from the cargo tank deck;

.7 metal sheaths or armours of cables shall be earthed at both ends. For final subcircuits earthing of the metal sheath may be effected only at the supply end.

19.2.6.3 In systems with voltages specified in **19.2.2.1.4**, only cables having copper screens with additional insulation covering may be used.

The cross-sectional area of a screen shall be at least the cross-sectional area of a conductor.

19.2.7 Integrated cargo and ballast systems.

19.2.7.1 These requirements are applicable to integrated cargo and ballast systems on tankers, irrespective of the size or type of the tanker.

Within the scope of these requirements, integrated cargo and ballast system means any integrated hydraulic and/or electric system used to drive both cargo and ballast pumps (including active control and safety systems and excluding passive components, e.g. piping).

19.2.7.2 Measures shall be taken to prevent cargo and ballast pumps becoming inoperative simultaneously due to a single failure in the integrated cargo and ballast system, including its control and safety systems.

19.2.7.3 The emergency stop circuits of the cargo and ballast pumps shall be independent from the circuits for the control systems. A single failure in the control system circuits or the emergency stop circuits shall not render the integrated cargo and/or ballast system inoperative.

19.2.7.4 Manual emergency stops of the cargo pumps shall be arranged in a way that they are not cause the stop of the power pack making ballast pumps inoperable.

19.2.7.5 The control systems shall be provided with a duplicate power supply from the main switchboard.

The failure of any power supply shall provide audible and visible alarm activation at each pump control location.

19.2.7.6 In the event of failure of the automatic or remote control systems, a secondary means of control shall be made available for the operation of the integrated cargo and ballast system.

This can be achieved by manual overriding and/or redundant arrangements within the control systems.

19.3 SHIPS INTENDED FOR CARRIAGE OF MOTOR VEHICLES WITH FUEL IN THEIR TANKS INCLUDING COMPRESSED HYDROGEN OR NATIONAL GAS FOR THEIR PROPULSION

19.3.1 General.

19.3.1.1 The requirements of this Chapter are applicable to electrical equipment of holds and other spaces and areas intended for the carriage of motor vehicles with fuel in their tanks necessary for their propulsion.

19.3.1.2 The holds and spaces specified in **19.3.1.1** belong to the category of dangerous spaces and zones.

19.3.1.3 Cables shall be protected against mechanical damage. Cables installed horizontally shall be positioned at a distance not less than 450 mm above the continuous deck or platform preventing a free propagation of gases in the downward direction. The sealings where cables penetrate bulkheads and deck shall be gastight.

19.3.1.4 Electrical equipment installed in ventilation ducts shall be of the following safe types: increased safety (Exe) or with flameproof enclosure (Exd) and be able to operate in the explosive gas environment and comply with IIC (compressed hydrogen) or IIA (compressed natural gas) gas mixture, refer to ДСТУ EN 60079-20-1 or relevant EN or IEC standards.

19.3.1.5 The lighting system in holds and spaces specified in **19.3.1.1** shall be arranged at least in two groups, each supplied separately from an independent circuit.

19.3.2 Installation of electrical equipment in holds and spaces intended for carriage of motor vehicles with fuel in their tanks in passenger ships and ferries.

19.3.2.1 In holds and compartments, in spaces located at a height of more than 450 mm above the cargo deck or platform preventing free penetration of gases downwards, it is allowed to install electrical equipment:

with the degree of protection at least IP55 provided the ventilation system ensures at least 10 air changes per hour;

specially designed for use in zone 2.

19.3.2.2 In holds and spaces above the bulkhead deck, in zones less than 450 mm above the deck or platform preventing, a free propagation of gases in the downward direction, electrical equipment installed shall be of the following safe types:

intrinsically safe (*Exi*), with pressurized enclosure (*Exp*), with flameproof enclosure (*Exd*) or increased safety (*Exe*).

19.3.2.3 In holds and spaces below the bulkhead deck all the electrical equipment shall be of the following safe types:

intrinsically safe (*Exi*), with pressurized enclosure (*Exp*), with flameproof enclosure (*Exd*) or increased safety (*Exe*).

19.3.3 Special requirements for passenger ships having ro-ro cargo spaces.

19.3.3.1 In passenger ships with roll-on/roll-off cargo spaces or special-category spaces as mentioned under 1.5, Part VI "Fire Protection", apart from emergency lighting required by **19.1.2.1.1**, additional emergency lighting shall be provided in all public spaces and corridors, that shall serve for 3 hrs at least under any heel of the ship and when all other electrical power sources fail.

This lighting shall make the escape routes clearly visible (or ensure an illumination intensity of 0,5 lx).

Any damage to a lighting fixture shall be clearly visible.

19.3.3.2 As electrical power sources for this additional lighting, accumulator batteries shall serve fitted in lighting fixtures, continuously recharged from the emergency distribution board and replaced within the period established by the manufacturer with regard to their service conditions.

19.3.3.3 In each corridor of crew spaces, in crew recreation rooms and in each space where the crew members generally work, a hand lamp (lantern) shall be provided supplied from an accumulator unless additional emergency lighting stipulated by **19.3.3.1** and **19.3.3.2** is installed in the space.

19.3.4 Installation of electrical equipment in holds and spaces intended for carriage of motor vehicles with fuel in their tanks in cargo ships.

19.3.4.1 In holds and compartments, in spaces located at a height of more than 450 mm above the cargo deck or platform preventing free penetration of gases downwards, it is allowed to install electrical equipment:

with the degree of protection at least IP55 provided the ventilation system ensures at least 10 air changes per hour;

specially designed for use in zone 2.

19.3.4.2 In holds, spaces and zones less than 450 mm above the cargo deck or platform preventing a free propagation of gases in the downward direction, electrical equipment installed shall be of the following safe types: intrinsically safe (*Exi*), with pressurized enclosure (*Exp*), with flameproof enclosure (*Exd*) or increased safety (*Exe*).

19.4 SPECIAL PURPOSE SHIPS

19.4.1 Supply of essential services.

In special purpose ships carrying more than 60 persons, the power supply of essential services shall comply with **19.1.1.4**.

19.4.2 Emergency sources of electrical power.

19.4.2.1 In special purpose ships carrying not more than 60 persons, the emergency source of electrical power shall comply with **9.3**.

Ships having a length above 50 m shall additionally comply with **19.1.2.3.1**.

19.4.2.2 In ships carrying more than 60 persons, the emergency source of electrical power shall comply with **19.1.2**.

19.4.3 Electrical equipment in storerooms for explosives.

19.4.3.1 Except for lighting fixtures in glass hoods and protection gratings and cables in gastight pipes, no electrical equipment shall be installed in storerooms for explosives specified in **2.1.5.3**, Part VI "Fire Protection".

19.4.3.2 Switches of lighting circuits shall be fitted outside storerooms for explosives and shall be provided with light signals to indicate the presence of voltage in the lighting fixtures.

19.4.3.3 In storerooms for explosives, the devices for connection of portable electrical equipment to the ship's mains shall be provided with nameplates indicating the rated electrical parameters and shall have a protective enclosure not below IP56 type.

19.4.3.4 Storerooms for explosives shall be fitted with automatic heat detectors operating at temperatures rising above 40°C (refer to **6.2.2.17**, Part VI "Fire Protection").

19.4.4 Ships used for processing the living resources of the sea and not engaged in their catching.

19.4.4.1 Survey of electrical equipment. In addition to the requirements of **1.3.2**, the electrical equipment of processing machinery (catch processing) is subject to survey on board the ship (refer also to **1.3.2.4.1**).

19.4.4.2 Survey during manufacture of electrical equipment. The electrical equipment of processing machinery specified in **19.4.4.1** is subject to survey during manufacture in addition to that listed in **1.3.3.1**.

Use of electrical equipment, specified in **19.4.4.1**, not fully complying with the requirements of Sections **1 - 18** is permitted.

19.4.4.3 Structural requirements and protection of electrical equipment of processing machinery and refrigerating plants.

19.4.4.3.1 The electrical equipment installed in catch processing spaces shall be resistant to seawater and fish processing products influence or shall be adequately protected against it.

19.4.4.3.2 The electric motors of the processing refrigerating compressors, fans of the refrigerated holds and freezing apparatus and, in well-grounded cases, the electrical equipment of other processing machinery shall be provided with heating arrangements to maintain a temperature which is at least by 3°C higher than the ambient temperature.

19.4.4.3.3 Distribution gear and start, control and protection devices of electrical equipment specified in **19.4.4.3.1** shall be installed in special electrical spaces.

19.4.4.3.4 Cables installed in spaces subjected to prolonged influence of salt and other products of fish processing shall be provided with sheaths resistant to such influence or be adequately protected.

19.4.4.4 Composition and capacity of main electrical power source.

19.4.4.4.1 Determination of the composition and capacity of the main source of electrical power shall determined with regard to the following operating conditions of the ship:

running conditions;

manoeuvring;

in case of fire, hole in the ship's hull or other conditions affecting the safety of navigation, with the main source of electrical power in operation;

processing.

19.4.4.4.2 The capacity of generators composing the main electrical power source shall be such that if any of them fail, the rest will ensure power supply of electrical equipment under conditions specified in **19.4.4.4.1**, as well as minimal habitable conditions to persons on board.

19.4.4.5 Distribution of electrical power.

19.4.4.5.1 Where the main electrical power source incorporates shaft generators not intended for operation in parallel with the independently driven generators, the machinery and systems ensuring propulsion, manoeuv-rability and safety of navigation shall be supplied from the busbars of independently driven generators, while the electrical equipment of processing refrigerating plant and machinery shall be supplied from the busbars of shaft generators.

19.4.4.5.2 The electric drives of processing refrige-rating compressors shall be supplied by separate feeders from the busbars of the main switchboard. It is admissible for these drives to be fed from a separate switchboard supplied by two feeders connected to different sections of the main switchboard.

19.4.4.5.3 Electrical circuit for supplying switchboards of the processing machinery (catch processing) shall be separated electrically (galvanically) from the ship's mains.

19.4.4.5.4 If provision is made for electrical power transmission to other ships, a power transmission switchboard separated electrically (galvanically) from the ship's mains shall be installed.

19.4.4.5.5 Where portable tools and movable mechanization facilities not permanently installed are supplied from a circuit of more than 50 V, a safety isolation device in combination with a separating transformer shall be used for each consumer. Such device shall interrupt power supply if the hull leakage current exceeds 30 mA.

19.4.4.6 Lighting.

19.4.4.6.1 Catch processing spaces and refrigerating machinery rooms shall be illuminated by stationary lighting fixtures, which shall be supplied and arranged in accordance with **6.2.3**.

19.4.4.6.2 Fish storage holds shall be illuminated with stationary lighting fixtures, which shall be supplied in accordance with **6.2.7**.

19.4.4.7 Signalling. A "Man-in-Hold" signal push-button shall be located inside the refrigerated holds at each exit to actuate signal at the wheelhouse or another permanent attended space in accordance with **7.22**.

19.4.4.8 Emergency electrical installations.

19.4.4.8.1 The emergency source of electrical power shall comply with the requirements of **9.3**.

19.4.4.8.2 In addition to the requirements of **9.3.1.1**, the emergency source of electrical power shall supply the emergency lighting for the catch processing spaces and the exits therefrom as well as for the deck in way of fishing machinery.

19.4.4.8.3 Where a generator is used as the emergency source of electrical power, an emergency transitional source of electrical power (accumulator battery) shall be provided, the capacity of which shall be sufficient to supply the consumers specified in **9.3.7** and **19.4.4.8.2** during 30 min.

19.5 CONTAINER SHIPS

19.5.1 General.

The requirements of the Chapter are applicable to the electrical equipment of ships intended for the carriage of thermal containers.

19.5.2 Supply and distribution of electrical power.

19.5.2.1 As the rated power of electrical equipment of thermal containers their prescribed power shall be taken. The consumed power of the electrical equipment of thermal container shall not exceed 15 kW (18,75 kVA) under rated operating conditions.

19.5.2.2 The overload protective device of sources of electrical power prescribed in **8.2.3** shall ensure disconnection of thermal containers from the main switchboard in the last turn (refer also to **20.2.1**).

19.5.2.3 The electrical circuit supplying the equipment of thermal containers shall be separated from the ship's mains by transformers with separate windings, fed from the main switchboard.

19.5.2.4 The electrical installations of thermal containers shall be fed from special distribution gear energized by separate feeders.

19.5.2.5 Socket outlets installed in cargo holds or on open decks in areas of stowage of thermal containers shall be supplied by separate outgoing feeders from the special distribution gear (switchboards) specified in **19.5.2.4** and **19.5.3.3**.

19.5.2.6 The electrical circuit of socket outlets intended for supply of the electrical installations of thermal containers shall be rated for 220/380 V voltage at 3-phase alternating current, 50 Hz in frequency, or for 240/440 V voltage at 3-phase alternating current, 60 Hz in frequency.

19.5.2.7 For each isolated network of sockets monitoring of insulation resistance shall be provided (refer to **2.11**).

19.5.3 Distribution gear and transformers.

19.5.3.1 The distribution gear (switchboards) of thermal containers, electrical converters, if any, and transformers with separate windings shall be installed in special electrical spaces.

19.5.3.2 The secondary winding of transformers with separate windings shall have an isolated zero point.

19.5.3.3 Each distribution gear (switchboard) shall be equipped with appliances, which ensure:

.1 visual signalling to indicate the presence of voltage;

.2 connection and disconnection of each outgoing feeder supplying the socket outlets;

.3 short-circuit protection at the outgoing feeders supplying the socket outlets;

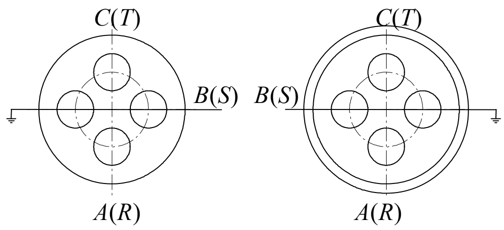
.4 measuring of insulation resistance with visible and audible alarm at the main machinery control room at decreasing of the controlled value below the specified level.

19.5.4 Socket outlets.

19.5.4.1 In holds containing thermal containers it is allowed to install socket outlets used only for power supply of containers with the degree of protection not less than IP55 type, and on open decks _ IP56 type. When the electrical systems of remote control over temperature, humidity, ventilation and other characteristics of thermal containers are used, it is permitted to install additional socket outlets for connection of these control devices in holds or on decks.

19.5.4.2 Socket outlets for power supply of the electrical equipment of thermal containers shall, in addition to requirements of 6.6, be fitted with an isolating switch interlocked so that the plug cannot be inserted or withdrawn while the switch is in the "on" position. A nameplate indicating the voltage shall also be fitted.

19.5.4.3 The electrical installation of thermal containers shall be supplied from the ship's mains at the direct sequence of phases A(R), B(S), C(T) according to the scheme given in Fig. 19.5.4.3.



Plug (front view)   Socket (front view)

19.5.4.4 Socket outlets intended for supply of the electrical installations of thermal containers shall be rated at the following currents:

63 A for voltage of 220 V, 50 Hz or 240 V, 60 Hz;

32 A for voltage of 380 V, 50 Hz or 440 V, 60 Hz.

19.5.4.5 Socket outlets shall be designed so as to prevent connection of plugs rated for one voltage to socket outlets rated for another voltage.

19.5.4.6 Design and dimensions of plugs and sockets shall correspond to international standards.

19.5.5 Protection earthing.

The receptacle intended for connection of the earthing conductor in the flexible cable of the thermal container shall be grounded through the earthing conductor in the supply feeder, where the distribution gear (switchboard) is installed for supply of socket outlets of thermal containers.

19.6 CATAMARANS

19.6.1 1 In each hull of the ship at least one generator being a part of the main source of electrical power shall be provided.

19.6.2 In each hull of the ship, a main distribution board shall be installed. One of the boards may be installed above the bulkhead deck.

19.6.3 The busbars supplying the ship hulls shall be sectioned.

19.6.4 The emergency services of each hull shall be supplied from the emergency source of electrical power through separate feeders.

19.6.5 The disconnecting switches of electrical equipment specified in **5.7.1**, **5.7.2**, **5.8.1**, **5.8.2** and **5.8.3**, shall be grouped separately for each hull.

19.7 FLOATING CRANES AND CRANE SHIPS

19.7.1 Where systems similar to those mentioned in Section 17 are used for crane machinery of floating cranes and crane ships, the requirements of this Section being also applicable to the electric drives of crane machinery, such systems fall, so far as practicable, under the relevant requirements of this Chapter.

19.7.2 For self-driven floating cranes, the capacity of the main source of electrical power shall be sufficient for the selective operation of the crane both underway and during cargo-handling operations.

19.7.3 Accumulator rooms, accumulator boxes and spaces containing emergency sources of electrical power may be located below the bulkhead deck, provided all the requirements of **9.2** and **13.2** are satisfied.

19.7.4 To produce sound signals during cargo-handling operations, a sound-signal means shall be fitted on the crane, activated from the operator's cabin.

19.8 FLOATING DOCKS

19.8.1 General.

The requirements of this Chapter cover the electrical equipment of steel floating docks in addition to the relevant requirements set forth in Sections **1–18**.

19.8.2 Survey of electrical equipment.

19.8.2.1 In addition to requirements of **1.3.2.1**, the following kinds of equipment, systems and devices are subject to survey on board the floating dock:

.1 electric drives and their systems of control and monitoring of the mechanisms ensuring submersion and emersion of the dock;

.2 earthing of the docked ship.

19.8.2.2 All kinds of electrical equipment used in steel floating docks and listed under **1.3.3.1** and **19.8.2.1** are subject to survey during manufacture.

For machinery and gear of non-autonomous docks, it is permitted to use the electrical equipment not fully complying with the requirements of Sections **1–18**.

19.8.3 Protective enclosures of electrical equipment.

Protective enclosures of the electrical equipment shall be in compliance with Table 2.4.4.2 considering that dry compartments of the dock wing walls refer to the spaces of increased humidity, and dry compartments of pontoons, tunnels in pontoons and other similar spaces refer to the extra humid category.

19.8.4 Earthing.

19.8.4.1 Each docked ship shall be earthed to the dock hull through at least two special flexible cable connectors having a cross-sectional area not less than 70 mm^2 each, and devices for connection thereof to the dock hull shall be provided at the dock.

19.8.4.2 To connect the dock hull to the shore earthing system, it is necessary to provide at least two flexible copper cables, having a cross-sectional area not less than 70 mm^2 each, and also a device for connection of these cables to the dock hull.

No metal earthing of the dock hull is allowed if a system of cathodic protection from corrosion is applied, and circuits of the dock are electrically separated from the shore circuits.

19.8.4.3 All sections of the dock hull, pontoons, wing walls and similar structures shall be electrically connected by reliable means.

19.8.5 Number and output of sources of electrical power.

19.8.5.1 Main sources of electrical power for docks may be as follows:

.1 for autonomous docks - intrinsic generators;

.2 for non-autonomous docks - shore electrical power system.

19.8.5.2 At least two generators and, in addition, a shore electrical power system, if necessary, shall be provided as main sources of electrical power on autonomous docks. For non-autonomous docks it is allowed to use only a shore electrical power system.

19.8.5.3 The power of main generators of autonomous docks or the power available from a shore electrical power system shall be sufficient to ensure the following operating conditions of the dock:

submersion of the dock;

docking of the ship;

emersion of the dock;

emergency condition;

other conditions in accordance with the dock's purpose.

19.8.5.4 The power of main generators of the autonomous dock shall be such that in case of failure of any generator the rest of the generators ensure safe submersion and emersion of the dock and also docking and undocking of ships.

19.8.6 Distribution of electrical power.

19.8.6.1 The following systems of electrical power distribution are allowed for use in docks in addition to those specified in **4.1.1**:

.1 three-phase four-wire alternating current system with earthed neutral wire;

.2 one-wire system, both alternating and direct current, with dock's hull return only for welding circuit (refer also to **19.8.4**), and also for devices of monitoring and measurement of insulation resistance.

19.8.6.2 In addition to **4.3.1** the following consumers shall be supplied by separate feeders from the main switchboard busbars energized directly by the generators proper or through the transformer, or by the shore electrical power system:

.1 system of monitoring, signalling and control of the dock submersion and emersion;

.2 switchboards for electric drives of the ballast system sluice valves associated with safe operation of the dock;

.3 switchboards for supply of welding outfit;

.4 switchboards for supply of the docked ship.

19.8.6.3 Essential consumers and electric drives of machinery situated at the wing wall where no source of electrical power is installed shall be supplied from the switchboard located therein. This switchboard shall be considered as a separate part of the main switchboard and shall be fed from the main switchboard by two feeders. The cross-section of each feeder shall be sufficient for supply of the wing wall essential consumers in case of failure of one feeder. The supply feeders shall run between wing walls in different spaces if it is permitted by the dock design.

In separate cases, installation of both feeders in one space may be allowed.

19.8.6.4 Signal marker lights may be supplied from lighting switchboards.

19.8.6.5 In case of high-voltage electrical power supply of the non-autonomous dock from the shore electrical power system, in addition to the high-voltage feeder a device shall be fitted for connection of the low-voltage supply feeder.

This device shall be designed for continuous transmission of electrical energy required at the idle dock when no repairs are carried out. In this case, provision shall be made for continuous supply of at least one electric drive of maximum capacity fire pump when fully loaded and also for supply of all electric motors of sluice valve drives and lighting of main spaces.

When high-voltage electrical power is supplied to the non-autonomous dock by two independent feeders, a low-voltage supply feeder need not be provided.

19.8.6.6 When the dock is supplied from the shore low-voltage electrical power system, it is required to provide two feeders and two devices for reception of electrical power, one of them supplying the consumers specified in **19.8.6.2** and the other - at least the consumers referred to in **19.8.6.5**.

19.8.6.7 Arrangement and design of devices for connection of cables used for power supply from the shore electrical power system shall be such as to ensure:

.1 installation of cables at an adequate distance from one another to prevent simultaneous damage of high-voltage and low-voltage feeders;

.2 absence of mechanical stresses in cables during submersion and emersion of the dock;

.3 prevention of transmission of mechanical stresses to the terminals intended for connection of cables or wires.

It is recommended that the devices for reception of electrical power from the shore electrical power system shall be located on different wing walls of the dock.

19.8.6.8 A bright and clear warning inscription indicating the voltage shall be made on the hull in a prominent position or on the door of the external supply switchboard.

19.8.6.9 The maximum permissible level of the short-circuit power shall be determined for each dock, which may be supplied from the shore electrical power system. This level shall be marked on the warning inscription of the external supply switchboard.

19.8.6.10 The docked ships shall be fed from the stationary supply switchboards installed in the dock.

19.8.6.11 Each supply switchboard of the docked ship shall be fitted with:

.1 switchgear and protective devices, terminals or plug and socket connectors for flexible cables connected to the docked ship. All the terminals of the switchboard shall bear a mark indicating a phase or pole;

.2 a pilot lamp indicating the presence of voltage across switchboard terminals;

.3 a nameplate indicating the nominal voltage, nature of current, its permissible value and frequency.

19.8.6.12 At the supply switchboard of the docked ship provision shall be made for the device for fastening the ends of the flexible cable feeding the docked ship.

19.8.6.13 Cross-sectional area of the flexible supply cable of the docked ship shall be chosen for rated current of the protection setting fitted in the outgoing feeders of the supply switchboard of the docked ships.

19.8.7 Transformers.

In floating docks one transformer of adequate power may be used for supply of the lighting circuit and circuits of essential consumers. In this case, it is recommended to provide for possible reserve supply of these consumers from the transformer intended for feeding the docked ships.

19.8.8 Lighting.

19.8.8.1 In addition to provisions of **6.6.1**, socket outlets for portable lighting fixtures shall be installed at least:

.1 in dry compartments of wing walls where equipment and outfit for the system of submersion and emersion of the dock is located;

.2 in spaces of safety deck where the equipment for the system of submersion and emersion of the dock is located;

.31 in the space where the central control console of the dock submersion and emersion is located;

.4 in the area of location of the mooring machinery electric drives.

19.8.9 Service telephone communication.

19.8.9.1 In the absence of other types of voice communication provision shall be made for telephones of the ship's control group, which ensure clear two-way communication between the following spaces:

.1 main machinery control room - warping capstans;

.2 main machinery control room - emergency diesel-generators space;

.3 main machinery control room - main switchboard space;

.4 main machinery control room - main diesel generator space;

.5 main machinery control room - high-voltage transformer space;

.6 main machinery control room - spaces of location of hand drives for sluice valves of the dock submersion and emersion system;

.7 main machinery control room - fire-extinguishing station.

In docks provision shall be made for connection of at least one telephone set to the shore telephone system.

19.8.10 General alarm system.

General alarm system shall be actuated from the main machinery control room and from the space intended for the personnel on watch, if such a space is provided.

19.8.11 Installation of cables.

19.8.11.1 If the pontoon deck is illuminated with lighting fixtures of submersible type and if the cables used are not light, they shall run to the lighting fixtures in water- and gastight pipes.

The pipes and their packings shall be selected with regard to operation under pressure not less than the permissible pressure of submersible lighting fixtures.

19.8.11.2 On special agreement with the Register, cables may be installed on tray plates (saddles) welded directly to the dock plating.

19.8.12 Distribution of electrical power and cabling with the use of one-wire system.

19.8.12.1 Relevant terminals of sources and consumers of electrical power shall be reliably connected to the dock hull. This connection shall not be made in pipelines, tanks and cylinders containing compressed gases, petrol and oil.

19.8.11.2 For direct-current circuit the insulated wire shall be connected to the positive poles and terminals of sources and consumers of electrical power.

Instruments, switchgear and protective devices shall be set to the positive pole.

19.8.12.3 Conductors used for connection of terminals of the electrical equipment and the dock hull shall be equal in cross-sectional area to the conductors isolated from the hull.

19.8.12.4 Points of connection of conductors to the steel hull of the dock shall be situated in areas and positions readily accessible for control and maintenance of contacts.

These points shall be located on structures, which are reliably joined by welding to the dock hull.

19.8.12.5 Working earthing conductors shall be joined in such a manner that reliable electrical connection to the hull is ensured.

It is recommended to use high-power busbars, which are connected to the dock hull in several points.

19.8.12.6 Regardless of the system of electrical power distribution used for welding circuit, the welding station in the docked ship shall be supplied by two-wire system from the welding circuit of the dock.

Hull return system of the docked ship is not permitted.

19.8.12.7 When carrying out welding operations on the hull of the docked ship, a cable with a potential opposite to that of the electrode shall be connected to the hull as close to the part being welded as possible.

19.8.13 Busbar conduits.

19.8.13.1 The application of busbar conduits is allowed for floating docks. The degree of protection of busbar conduits depending on the place of installation shall comply with the requirements of **2.4.4.2**.

19.8.13.2 Busbar conduits shall be designed for adequate load and shall withstand, along with insulators and holders, mechanical stresses resulting from short-circuit current directly at busbars.

19.8.13.3 At alternating current exceeding 1500 A, provision shall be made for reduction of the current loss in busbar holders, fixtures, insulators and structures which results from the influence of magnetic fields.

19.8.13.4 All protective devices and switchgear connected immediately to the busbar conduit shall be installed in places accessible for inspection and repair. Cables and busbars connecting the protection devices and the busbar conduit shall not be more than 2 m in length.

19.8.13.5 Busbar conduits with the degree of protection IP20 and below shall be installed at a height not less than 2,5 m above the floor level.

19.8.13.6 Warning inscriptions indicating the voltage shall be made on the protective enclosure of the busbar conduit at 3 to 5 m intervals throughout the whole length.

19.8.14 Emergency electrical installations.

19.8.14.1 Each floating dock shall be provided with an emergency source of electrical power ensuring power supply of all the necessary consumers for not less than 3 h.

19.8.14.2 Emergency source of electrical power shall ensure supply of consumers as per 9.3.1, which are installed on board the dock, and also supply of the following consumers:

.1 electrical drives essential for sluice valves of the system of the dock submersion and emersion (at least 2 closings and openings of the sluice valves);

.2 indication and control circuits of the system of the dock submersion and emersion;

.3 command service communication.

19.8.14.3 If the emergency source of electrical power is a diesel generator with an automatic starting system, provision shall be made for local starting of the diesel generator.

19.8.14.4 The emergency diesel generator space shall be located above the margin line of the dock and be easily accessible from the open deck.

19.8.14.5 All the emergency consumers shall be supplied from the emergency switchboard.

In well-grounded cases, the emergency diesel generator and emergency switchboard may be installed in different spaces, and also one section of the main switchboard may be used as an emergency switchboard, provided the main switchboard is located above the level of the margin line of the dock.

19.8.15 Electric drives of submersion and emersion system of the dock.

19.8.15.1 Electric drives for sluice valves of the submersion and emersion system shall not hinder manual opening and closing of sluice valves. Interlocking device shall be also provided to prevent the electric drive from operation in case of sluice valve change-over to manual control.

19.8.15.2 Electric drives for sluice valves shall be fitted with local and remote-controlled (in the main machinery control room, etc.) indicators of sluice valve limit positions.

For electric drives of sluice valves intended for water distribution in the pontoon compartments it is also recommended to provide for devices indicating the extent to which the sluice valve is open.

19.8.15.3 For sluice valves intended for water distribution in the pontoon compartments it is recommended to provide for separate control of each sluice valve, as well as for group control of port and starboard sluice valves.

19.8.15.4 Control circuit for electric drives of the drain (ballast) pump shall provide for local and remote control from the main control station with indication of the pump operation or control of electric motor load on the ammeter.

19.8.16 Connection of electrical power supply sources.

When generators of the autonomous dock or transformers of the shore power supply are connected directly to the distribution busbar conduit, and the main switchboard is not installed, provision shall be made for a common control desk fitted with control gear for circuit breakers of generators or transformers and with instruments and devices of control, signalling and protective systems.

These instruments and devices are listed in **4.6**.

19.8.17 High-voltage electrical installation of the dock.

19.8.17.1 High-voltage electrical installation of the dock shall comply with the requirements of national standards and rules applicable to the shore electrical installations.

19.8.17.2 High-voltage electrical installation of the dock shall be located in separate special electrical spaces.

19.9 BERTH-CONNECTED SHIPS

19.9.1 For berth-connected ships, the following sources may be used as main sources of electrical power:

.1 generators;

.2 shore electrical power system.

19.9.2 On independent berth-connected ships, provision shall be made for at least two generators as main sources of electrical power. In addition, the ship mains may be supplied from the shore electrical power system.

Berth-connected ships that are not independent may be supplied from the shore electrical-power system only.

19.9.3 On independent berth-connected ships, the power of generators of the main power source or the power supplied by the shore electrical power system shall be sufficient for the operation of services in accordance with the ship purpose, in case of fire, hull leakage or other circumstances adversely affecting the safety of the berth-connected ship while the main source of electrical power is in operation.

19.9.4 The main generator power of an independent berth-connected ship shall be sufficient to ensure operation in accordance with **19.9.3** in the case of failure of any of the generators.

19.9.5 In floating hotels and hostels, power supply and signalling functions of essential systems and gear shall be effected in conformity with **19.1.1.1** to **19.1.1.4**.

The side, bow and stern lights may be supplied from lighting switchboards.

19.9.6 Each floating hotel or hostel shall be provided with an independent emergency source of electrical power to ensure the operation of services in accordance with **19.1.2.1** during 12 h, as well as the operation of services in accordance with **19.1.2.3** during 30 min.

19.9.7 As regards the automatic starting of the emergency source of electrical power and provision of an emergency transitional source in floating hotels and hostels, the requirements of **19.1.2.4** to **19.1.2.7** shall be complied with.

19.10 FISHING VESSELS

19.10.1 Survey of vessel's electrical equipment.

19.10.1.1 In addition to the requirements of **1.3.2** the following kinds of equipment, systems and devices are subject to survey on board the ship (refer also to **1.3.2.4.2**):

.1 electrical equipment of fishing machinery;

.2 electrical equipment of processing machinery (catch processing).

19.10.2 Survey during manufacture of electrical equipment.

The electrical equipment specified in **19.10.1.1** is subject to survey in addition to that listed in **1.3.3.1**.

The use of electrical equipment of general purpose industrial production specified in **19.10.1.1.2** not fully complying with the requirements of Sections **1 - 18** is permitted.

19.10.3 Structural requirements and protection of electrical equipment of fishing and processing machinery.

19.10.3.1 The electrical equipment installed in catch processing spaces shall be resistant to sea water and fish processing products influence or shall be adequately protected against it.

19.10.3.2 Electrical equipment distribution gear and start-protection devices specified in **19.10.3.1** shall be installed in spaces separated from catch processing spaces.

19.10.3.3 Cables installed in spaces subjected to prolonged influence of salt and other products of fish processing shall be provided with sheaths resistant to such influence or be adequately protected.

19.10.4 Composition and capacity of main electrical power source.

19.10.4.1 The composition and capacity of the main source of electrical power shall be determined with regard to the following operating conditions of the vessel:

.1 running conditions;

.2 manoeuvring;

.3 in case of fire, hole in the ship's hull or other conditions affecting the safety of navigation, with the main source of electrical power in operation;

.4 fishing.

19.10.4.2 The capacity of generators composing the main electrical power source shall be such that if any of them fail, the rest will ensure power supply of electrical equipment necessary under conditions specified in **19.10.4.1** as well as minimal habitable conditions to persons on board.

In well-grounded cases, in vessels of less than 500 gross tonnage the capacity necessary to ensure fishing operations and/or catch processing may be neglected.

19.10.5 Distribution of electrical power.

19.10.5.1 Where the main electrical power source incorporates shaft generators not intended for parallel operation with the independently driven generators, the machinery and systems ensuring propulsion, manoeuvrability and safety of navigation shall be supplied from the busbars of independently driven generators, while the electrical equipment of fishing and processing machinery shall be supplied from the busbars of shaft generators.

19.10.5.2 The electric drives of refrigerating compressors shall be supplied by separate feeders from the busbars of the main switchboard. It is admissible for the electric drives of refrigerating compressors to be fed from a separate switchboard supplied by two feeders connected to different sections of the main switchboard.

19.10.5.3 Where portable tools and movable mechanization facilities not permanently installed, are supplied from a circuit of more than 50 V, a safety isolation device in combination with a separating transformer shall be used for each consumer. Such device shall interrupt power supply if the hull leakage current exceeds 30 mA.

19.10.6 Lighting.

19.10.6.1 Catch processing spaces and refrigerating machinery rooms shall be illuminated by stationary lighting fixtures, which shall be supplied and arranged in compliance with **6.2.3**.

19.10.6.2 Fish storage holds shall be illuminated by stationary lighting fixtures, which shall be supplied in accordance with **6.2.7**.

19.10.7 Signalling.

A "Man-in-hold" signal push-button shall be located inside the refrigerated holds at each exit to actuate signal at the wheelhouse or another permanently attended space in accordance with **7.22**.

19.10.8 Emergency electrical installations.

19.10.8.1 The emergency source of electrical power shall comply with **9.3**.

19.10.8.2 In addition to the requirements of **9.3.1.1**, the emergency source of electrical power shall supply the emergency lighting for the catch processing spaces and the exits therefrom as well as for the deck areas where the fishing machinery is installed.

19.10.8.3 Where a diesel generator is used as the emergency source of electrical power, an emergency transional source of electrical power (accumulator battery) shall be provided, the capacity of which shall be sufficient to supply the consumers specified in **9.3.7** and **19.10.8.2** during 30 min.

19.11 SHIPS CARRYING DANGEROUS GOODS

19.11.1 General.

19.11.1 The requirements of this Chapter, in addition to the requirements of 7.2, Part VI "Fire Protection", apply to the electrical equipment of ships and cargo spaces intended for the carriage of dangerous goods.

19.11.2 Dangerous zones, spaces and areas.

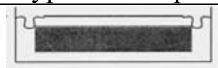
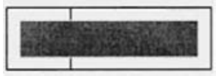
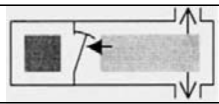
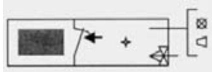
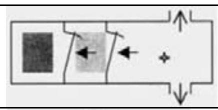
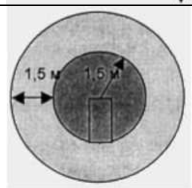
19.11.2.1 Classification of dangerous zones.

Zone 1, in which an explosive gas/air mixture is likely to occur in normal operation.

Zone 2, in which an explosive gas/air mixture is not likely to occur, and if it occurs, it will only exist for a short time.

Typical examples of arrangement of the dangerous zones are given in Table 19.11.2.1.

Table 19.11.2.1. **Dangerous zones for dangerous goods**

Subparagraphs	Typical examples	Comments
19.11.2.2; 19.11.2.3.1, **19.11.2.4.1.1** **19.11.2.5.1.1**		-
19.11.2.3.2 **19.11.2.4.1.2** **19.11.2.5.1.2**		-
19.11.2.4.1.4 **19.11.2.5.1.4**		-
19.11.2.4.2.1 **19.11.2.5.2.1**		*
		**
19.11.2.4.2.1 **19.11.2.5.2.1** -only for fore room		*
19.11.2.4.1.3 **19.11.2.5.1.3,** **19.11.2.4.2.2** **19.11.2.5.2.2**		

* natural ventilation

** space under overpressure, visual and audible alarm in control stations to be actuated when pressure drops

	gastight self-closing door
	non-dangerous space
	dangerous zone 1
	dangerous zone 2

19.11.2.2 For packaged dangerous goods, Class 1, except of subclass 1.4S, the dangerous zones encompass the following spaces and areas classified as Zone 1:

.1 enclosed spaces of cargo compartments/holds as well as open or enclosed ro-ro cargo spaces;

.2 integral storerooms for the ship's stock of explosives.

19.11.2.3 For dangerous goods carried in bulk, Class 4.1, 4.2, 9 and MHB (Materials Hazardous in Bulk) capable of producing explosive dust/air mixtures, the dangerous zones encompass the following spaces and areas classified as Zone 1:

.1 enclosed spaces of cargo compartments/holds;

.2 air ducts of ventilation systems for spaces of cargo compartments/holds specified in **19.11.2.3.1**.

19.11.2.4 For dangerous goods carried in bulk, Class 4.3, capable of producing explosive gaseous mixture, the dangerous zones encompass the following spaces and areas: **19.11.2.4.1** Zone 1:

.1 enclosed spaces of cargo compartments/holds;

.2 air ducts of ventilation systems for spaces of cargo compartments/holds specified in **19.11.2.4.1.1**;

.3 areas on open deck or semi-enclosed spaces on open deck within 1,5 m of any ventilation outlets of cargo compartments/holds specified in **19.11.2.4.1.1**;

.4 enclosed or semi-enclosed spaces having direct access to or other openings into spaces and areas specified in **19.11.2.4.1.1**, **19.11.2.4.1.2**, unless approp-riate measure are taken to prevent the explosive mixture from penetration into these spaces;

.5 air ducts of ventilation systems, pipelines of bilge systems, etc. where open ends of this piping directly face dangerous zone 1.

19.11.2.4.2 Zone 2

.1 enclosed or semi-enclosed spaces with natural ventilation, having direct access to or other openings into spaces and areas specified in **19.11.2.4.1.1**, **19.11.2.4.1.2** and separated from these spaces by gastight self-closing doors as well as directly within air lock, if any;

.2 areas within 1,5 m of areas and spaces on open deck specified in **19.11.2.4.1.3**;

.3 closed spaces (e.g. pipe tunnels, pump rooms with bilges, etc.) with piping specified in **19.11.2.4.1.5** along with their flanges, valves, pumps, etc. except cases when special methods of pressure buildup approved by the Register are used in those spaces.

19.11.2.5 For packaged dangerous goods, Class 2.1 and also Classes 3, 6.1 and 8 (liquids with $T_{flash} \leq 23°C$) the dangerous zones encompass the following spaces and areas.

19.11.2.5.1 Zone 1:

.1 enclosed spaces of cargo compartments/holds;

.2 air ducts of ventilation systems for spaces of cargo compartments/holds specified in **19.11.2.5.1.1**;

.3 areas on open deck or semi-enclosed spaces on open deck within 1,5 m of any ventilation outlets of cargo compartments/tanks specified in **19.11.2.5.1.1**;

.4 enclosed or semi-enclosed spaces having direct access to or other openings into one of the above areas specified in **19.11.2.5.1.1** and **19.11.2.5.1.2**, unless appropriate measure are taken to prevent the explosive mixture from penetration into these spaces;

.5 air ducts of ventilation systems, pipelines of bilge systems, etc. where open ends of this piping directly face dangerous zone 1.

19.11.2.5.2 Zone 2:

.1 enclosed or semi-enclosed spaces with natural ventilation having direct access to or other openings into spaces specified in **19.11.2.5.1.1**, **19.11.2.5.1.2** and separated from these spaces by gastight selfclosing doors, as well as directly within air lock, if any;

.2 areas within 1,5 m of areas or spaces on open deck specified in **19.11.2.5.1.3**;

.3 enclosed spaces (e.g. pipe tunnels, pump rooms with bilges, etc.) containing pipes specified in 19.11.2.5.1.5 along with their flanges, valves, pumps, etc.

Except for the cases where forced ventilation with 6-time air change is used in those spaces.

19.11.3 Installation of electrical equipment in dangerous spaces and zones.

19.11.3.1 Electrical equipment installed in spaces and areas where only explosive dust is likely to occur due to bulk cargoes, shall comply with the following minimum requirements, unless otherwise specified (refer to Table 19.11.3.2):

.1 protection level IP55 and the maximum surface temperature of 200°C or,

.2 certified safe type with temperature class T3 and protection level IP55.

19.11.3.2 Electrical equipment installed in areas where only explosive gas atmosphere is likely to occur shall be of certified safe type and comply with the following minimum requirements, unless otherwise specified (refer to Table 19.11.3.2):

.1 temperature class T3;

.2 sub-group of equipment IIB. The certified safe-type electrical equipment shall be at least with protection suitable for operation in Zone 1.

19.11.3.3 Electrical equipment installed in spaces and areas where only solid bulk cargoes and MHB (Materials Hazardous in Bulk) are carried shall comply with the requirements of **19.11.3.1**, **19.11.3.2** and the minimum requirements of Table 19.11.3.3.

19.11.3.4 Electrical equipment installed in spaces and areas where explosive gas atmosphere and dust are likely to occur shall comply with the requirements of **19.11.3.1** and **19.11.3.2**.

Table 19.11.3.3 **Requirements for electrical equipment depending on specific solid bulk cargoes.**

Dangerous goods	**IMO class**	**Dominant risk**[1]	**Protection against explosive dust**	**Protection against explosive gas atmosphere**	
				Subgroup A	Temperature class
1	**2**	**3**	**4**	**5**	**6**
Aluminium dross	4.3	Hydrogen	—	IIC	T2
Aluminium ferrocilicon powder	4.3	Hydrogen	—	IIC	T2
Aluminium cilicon powder, uncoated	4.3	Hydrogen	—	IIC	T2
Ammonium nitrate fertilizers:		Refer to footnote[2]			
type A	5.1		—	—	—
type B	9		—	—	—
Coal	MHB[3]	Dust, methane	IP55	IIA	T4
Direct-reduced iron	MHB	Hydrogen	—	IIC	T2
Ferrophosphorus (no briquettes)	MHB	Hydrogen	—	IIC	T1
Ferrocilicon	4.3	Hydrogen	—	IIC	T1
Iron oxide, spent. Sponge iron, spent	4.2	Dust	IP55	IIA	T2
Seed cake, expelled	4.2	Hexane	—	IIA	T3
Silicomanganese	MHB	Hydrogen	—	IIC	T1
Sulfur	4.1	Inherent	IP55	—	T4
Zinc slag	4.3	Hydrogen	—	IIC	T2

[1] This column relates to the possible evolution of substances, which may affect the installations of electrical equipment and cables.
[2] Provision shall be made to disconnect all electric circuits terminating within cargo spaces in accordance with the provisions of **2.9.9**.
[3] MHB – materials hazardous in bulk.

19.11.3.5 Electrical equipment installed in spaces and areas where dangerous goods of Class 1, except for Class 1.4S, are likely to be carried, shall comply with the following requirements:

.1 protection level IP65;

.2 the maximum surface temperature - 100°C.

19.11.3.6 Electrical equipment installed in dangerous zone of category 2 shall be:

.1 of type suitable for use in adjacent spaces in accordance with **19.11.3.1** to **19.11.3.5**; or

.2 of special design for protection class "*n*" and appropriate temperature class, sub-group and protection level in accordance with **19.11.3.1** to **19.11.3.5**; or

.3 of such design that does not generate arcs or sparks in service and which surfaces do not reach unacceptable high temperatures under normal conditions.

Where the spaces certified for zone 2 is protected with redundant mechanical ventilation capable of starting automatically electrical equipment not certified for zone 2 may be installed provided its automatically disconnected following loss of ventilation. In addition to the above, the manned stations shall be provided with audible and visual alarms activated at the failure in the ventilation system.

For primary essential services such as bilge and ballast ones, the electrical equipment shall be with the certified safe-type electrical equipment with protection suitable for operation in dangerous zone of category 2.

19.11.3.7 Portable electrical equipment shall, in general, have its own independent source of electrical power (except for intrinsically safe electric circuits) and be of certified safe type with protection suitable for operation in Zone 1.

20. REQUIREMENTS FOR ELECTRICAL EQUIPMENT OF REFRIGERATING PLANTS

20.1 GENERAL

20.1.1 The requirements of the Section cover the electrical equipment of classed refrigerating plants.
The requirements of **20.2.3**, **20.2.4**, **20.3.1** and **20.4** apply to unclassed refrigerating plants as well.

20.2 POWER SUPPLY AND SWITCHING

20.2.1 The electric drives of refrigerating plants shall be powered through separate feeders from the switchboard of the refrigerating plant.

The electric drives of refrigerating compressors may be supplied directly from the main switchboard.

The refrigerating fans may be supplied from the switchboard of the refrigerating plant or other switchboard energized directly from the main switchboard.

For each method of power supply it is necessary to provide that in case of generator overload the refrigerating plant electric drives are disconnected in the last turn.

The emergency ventilation system shall be supplied through a separate feeder from the switchboard energized from the main switchboard or directly from the main switchboard.

20.2.2 Power supply of electric drives of thermal containers shall comply with the requirements of **19.5.2**.

20.2.3 When using the refrigerants of Group II according to Table 2.2.1, Part XII "Refrigerating Plants", a device shall be provided for emergency remote disconnection of the refrigerating plant switchboard operated from the following locations:

.1 from the permanent control post of the refrigerating plant in the refrigerating machinery room;

.2 from a location outside the space that may be contaminated with the refrigerant of Group II in case of breakdown in the refrigerating machinery room;

.3 outside, near every exit from the refrigerating machinery room.

The apparatus for emergency remote disconnection shall be installed in such a manner that it cannot be actuated inadvertently.

20.2.4 The apparatus for emergency remote disconnection of the switchboard of the refrigerating plant working with Group II refrigerant shall simultaneously switch off the electric drives of refrigerating compressors if they are fed from the main switchboard (refer to **20.2.1**), main lighting of the refrigerating machinery compartment and switch on the emergency ventilation, water screens and reserve lighting.

Additionally, near the device for emergency remote disconnection of the refrigerating plant switchboard at locations stated in **20.2.3.1** and **20.2.3.2**, devices shall be installed for remote starting in any sequence of emergency ventilation, water screens, and reserve lighting, without disconnection of the refrigerating plant switchboard.

20.2.5 It is recommended that the electrical heating appliances for hatches and doors to refrigerated spaces and freezing chambers shall be supplied at safety voltage.

20.3 VENTILATION

20.3.1 If the refrigerant of Group II is used, the exhaust fan electric motors of the emergency ventilation in the refrigerating machinery rooms, installed in the exhaust ducts, shall be of safe type.

20.3.2 The electric motors of fans located in the stream of air coming from the refrigerated cargo spaces shall have a degree of protection not below IP55.

20.4 LIGHTING

20.4.1 If the refrigerant of Group II is used, safe-type reserve lighting fixtures shall be installed in the refrigerating machinery room in addition to the main lighting fixtures in accordance with the requirements of **2.9.3**, **2.9.11** and **2.9.13**. The reserve lighting fixtures shall be powered separately from the electrical equipment and main lighting fixtures installed in the refrigerating machinery room.

21 SPARE PARTS

21.1 Every ship shall be provided with spare parts in the amount sufficient for repairing when essential services fail at any situation, an accident at sea inclusive, in order to ensure movement, control and safety of a ship and people on board.

21.2 Specifying a required minimum of spare parts, the recommendations of manufacturers of specific kinds of equipment shall be followed.

22. SPECIAL REQUIREMENTS FOR ELECTRICAL EQUIPMENT OF SHIP'S ELECTRIC POWER SYSTEM WITH ELECTRICAL POWER DISTRIBUTION FOR DIRECT CURRENT

22.1 GENERAL

22.1.1 These requirements shall apply to the ship electric power d.c. distribution systems with voltage up to 1500 V measured between the pole terminals.

22.1.2 For the ship electric power d.c. distribution system the use of auxiliary sources and items of alternative three-phase current complying with the applicable sections of this Part of the Rules is permitted.

22.1.3 Both direct current generator and rectifier supplied from the alternating current generator may be the sources of d.c. electrical power.

22.1.4 In addition to the system for insulation resistance monitoring specified in **2.11**, the portable devices for search of insulation fault location shall be applied.

22.2 CONNECTION SYSTEMS OF ELECTRIC POWER SUPPLY UNITS

22.2.1 In addition to the requirement to subdivide the d.c. main busbar into two parts, specified in **3.5.6**, it is allowed to use two independent main switchboards interconnected by cable jumpers or bus cables. Automatic switches shall be provided on both ends of the cable jumper or bus cable. In this case, connection of generators and duplicated consumers shall be symmetrically distributed between the main switchboards, where practicable.

22.3 ELECTRICAL POWER DISTRIBUTION

22.3.1 Distribution systems and permissible voltage.

22.3.1.1 In the ship electric power d.c. distribution systems and the unified electric power d.c. distribution plants only the application of two-wire insulated system of electrical power distribution is allowed.

22.3.1.2 The permissible d.c. voltage at the terminals of electric power sources shall not exceed 1500 V.

22.3.1.3 At least two voltmeters shall be provided for d.c. main switchboard. In case d.c. main switchboards are divided, each part shall be fitted with a voltmeter.

22.3.1.4 One ammeter and one voltmeter shall be provided for each rectifier supplying d.c. busbars.

22.3.2 Power supply of essential consumers.

22.3.2.1 Essential consumers may be supplied from the d.c. power distribution box via the converter or from the separate a.c. distribution box supplied from the a.c. generators complying with the requirements of 3.1 and 3.2.

22.3.3 Distribution box arrangement.

22.3.3.1 D.c. main switchboard, generator sets and rectifiers shall be located in close vicinity to each other, as stated in **4.6.6.5**.

22.3.4.Calculation of short-circuit currents.

22.3.4.1 In the calculation of maximum and minimum short-circuit currents, a short-circuit source, in addition to those specified in **4.6.3.2**, shall contain all other devices (special electromechanical and electrical condenser-type power storages, for example, a.c.-d.c. (d.c.-a.c.) motor generators, filters with capacitors of large total capacity) operating simultaneously and able to produce current contribution to the short-circuit point.

Calculation for d.c. distribution gear shall be made for a solid short-circuit fault between conductors of opposite polarity.

Short-circuit currents shall be calculated for all circuits, in accordance with **4.6.3.2**, including fuses, automatic circuit breakers, and other electrical equipment, as well as for points on the busbars of a d.c. switchboard.

22.3.4.2 Since the circuits contain short-circuit currents of capacitors and capacitor banks, a shortcircuit process may be accompanied by resonant currents resulting from power exchange between capacitators and inductive elements in these circuits. Therefore, it is recommended to use software and computer simulation of relevant systems or their equivalent fragments in short-circuit current calculation.

Short-circuit current calculation shall be performed in a circuit from rectifier's output terminals to main switchboard's busbars, at outputs of an automatic circuit breaker, and directly on main switchboard's busbars. In the latter case current contribution of all main circuits shall be calculated.

22.3.4.3 Results of short-circuit calculation for individual circuits shall contain the list of selected electrical switching devices, fuses, and their ratings, including, for selective circuit breakers, permissible thermal withstand values I^2t.

To confirm feasibility of a protective function by the selected equipment, the list shall contain design values of maximum and minimum short-circuit currents, as well as on-site design values I^2t of protective devices, for a corresponding time equal to a trip setting.

Protection of the equipment against short-circuit currents with protective devices shall be assessed by comparison of the rated thermal withstand value I^2t to the relevant design thermal withstand value for a short-circuit current flowing during the time equal to the trip setting of the switch.

22.4 PROTECTION DEVICES

22.4.1 Faults on the d.c. generator side.

22.4.1.1 When the protection specified in 8.2.6 is activated, the generator shall be shut off from the main switchboard and its excitation shall automatically be removed.

22.4.2 Faults on the rectifier side.

22.4.2.1 The rectifiers shall be fitted with protection devices against the pole-to-pole fault in the cable or bus cable connecting the rectifier and the main switchboard.

22.4.2.2 Residual current devices shall be applied to control earthing of the poles in equipment and feeders of direct current system,

22.4.2.3 An audible and visual alarm shall be activated in the system at any earth faults.

22.4.3 Protection of capacitors.

22.4.3.1 Capacitive power storages (capacitors and capacitor banks) of d.c. distribution gear shall be fitted with quick-response short-circuit current protection per each section and a slower one at the storage input/output.

22.4.3.2 D.c. link capacitors of semiconductor inverters of the electric drive powered from d.c. distribution gear shall be locked with diodes, when possible, to remove or reduce the contribution with discharging current and the one generated by an electrical machine in case of shirt-circuit in a source.

When it is not possible, connection to a distribution device shall be ensured via protective elements of quicker response.

22.5 ELECTRICAL MACHINES.

22.5.1 D.c. generators and electric motors of nominal rated power 1000 kW and above shall be fitted with differential protection devices. For this purpose, a separate lead box shall be provided on a motor casing, located on the opposite side from the main box the slots for the sensors of differential protection shall be provided.

22.5.2 A.c. generators and built-in rectifiers may be provided with common cooling system.

22.6 A.C. POWER SUPPLY CONSUMER TRANSFORMERS.

22.6.1 Transformers fed from the converters and used as power source shall comply with the rate parameter of permissible stress rate while feeding from the pulse sources.

22.7 ELECTRICAL POWER CONVERTERS

22.7.1 Heat transfer from power semiconductor elements of converters for d.c. distribution may be performed both by the air cooling system and liquid air coolers.

22.7.2 The rectifiers intended for the parallel operation shall be capable of equal load distribution including short-term load.

22.7.3 The voltage at the uncontrolled rectifier output may be maintained by the excitation system of the generator to be used as power source for the rectifier.

22.7.4 The rectifiers of d.c. power sources shall contain a device for overshoot suppression and reception of excess power at the rectifier outlet connected to d.c. distribution qew.

22.7.5 As the rectifiers of d.c. electrical power source, the active controlled rectifiers constructed by the power source principle with the possibility to stabilize the output voltage and the additional function of reactive power compensation at the input may be applied.

22.7.6 In d.c. input circuit the inverters of the main propulsion plant shall be fitted with a device for overvoltage limitation and reception of surplus power from the electric drive in the regeneration mode.

22.7.7 In the output circuits of inverters the filters shall be installed to limit the stress rate up to the permissible level and to protect the coil insulation of the electric machine or transformer connected to the inverter.

22.8 ELECTRIC PROPULSION PLANTS

22.8.1 The electric propulsion plant supplied from and using a.c. electrical power includes the following devices:

.1 a.c. (or d.c.) main generators with their control devices – at least 2;

.2 a semiconductor converter-rectifier (may be built in the generator case, and is not used in case of power supply from a d.c. generator), either controlled or uncontrolled one, one per generator

.3 main switchboard separated in two parts with a section circuit breaker or break switch;

.4 storages compensating for power deficiency or excess;

.5 semiconductor converters - inverters of an electric propulsion plant for a.c. supply to stator windings of propulsion motors (or d.c. converters for d.c. supply to propulsion motor armature windings) – at least 2;

.6 arrangements (units) of control or controller of electric propulsion plants – at least 2;

.7 electric propulsion motor – one or more.

For electric propulsion plants with one propulsion motor, it is necessary to provide two systems of stator windings, each powered from its own semiconductor inverter, or two armature windings, each powered from its own d.c. voltage converter.

22.8.2 At least two, totally independent, stand-alone semiconductor frequency converters (or, respectively, two inverters powered from the d.c. switchboard or two d.c. voltage converters) to power individual winding systems of the propulsion motor (or separate motors) shall be provided for the electric propulsion plant.

If the converter feeds a permanently excited electric propulsion motor of direct or alternating current (including those excited from permanent magnet), a quick-response protection device, for example, a switch disconnector, shall be fitted in the «converter – motor” line, which, in response to a signal from the diagnostic device, shall open automatically in case of failure of a rectifier, an inverter of a semiconductor frequency converter, or short-circuit at the inverter input supplied from the d.c. switchboard.

22.8.3 Circuits of each individual filter maintaining harmonic distortion levels within acceptable limits shall be protected against over-currents and short-circuit currents.

When designing power filters, the possibillity of integrating into the circuits of additional elements to reduce current contribution from capacitors and their variability in short-circuit conditions of external circuits. Integrity of fuses in filter circuits shall be monitored. In case of any fuse burnout, an alarm warning system shall be activated.

22.8.4 Short-circuit and overload protection of the motor may be provided by an inverter or a power regulator connected to the d.c. switchboard.

Difference in designs of propulsion electrical machines (synchronous motor, permanent-magnet d.c. motor, asynchronous motor, switch reluctance motor or d.c. motor) shall be taken into account.

23. REQUIREMENTS TO ELECTRICAL EQUIPMENT OF SHIPS USING GASES OR LOW-FLASHPOINT FUELS

23.1 General.

23.1.1 Electrical equipment shall meet the requirements of Part VII "Electrical Equipment" of the Rules for the Classification and Construction of Ships Carrying Liquefied Gases in Bulk.

The hazardous zones shall be classified in accordance with **23.2**.

23.2 Classification of hazardous zones, spaces and areas.

23.2.1 The classification of hazardous zones shall be in compliance with IEC 60079-10 and IEC 60092-502. If a dangerous space is not covered by **23.2**, refer to the above standards.

23.2.2 Zone 0:

: the internal areas of gas fuel storage tanks, gas fuel pipelines, pipelines from safety valves of gas fuel storage tanks and any air pipelines from equipment containing gas.

23.2.3 Zone 1:

- tank connection spaces, fuel storage hold spaces and interbarrier spaces;
- fuel preparation rooms arranged with ventilation according to **12.14.4** Part VIII «Systems and Piping»;
- areas on open deck, or semi-enclosed spaces on deck, within 3 m of any fuel tank outlet, gas or vapour outlet, bunker manifold valve, other fuel valve, fuel pipe flange, fuel preparation room ventilation outlets and fuel tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation;
- areas on open deck or semi-enclosed spaces on deck, within 1,5 m of fuel preparation room entrances, fuel preparation room ventilation inlets and other openings into zone 1 spaces;
- areas on the open deck within spillage coamings surrounding gas bunker manifold valves and 3 m beyond these, up to a height of 2,4 m above the deck;
- enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes, semi-enclosed bunkering stations;
- the ESD-protected machinery space is considered a non-hazardous area during normal operation, but will require equipment required to operate following detection of gas leakage to be certified as suitable for zone 1;
- a space protected by an airlock is considered as non-hazardous area during normal operation, but will require equipment required to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1;
- except for type C tanks, an area within 2,4 m of the outer surface of a fuel containment system where such surface is exposed to the weather..

Notes: 1. Fuel storage hold spaces containing type C tanks with all potential leakage sources in a tank connection space and having no access to any hazardous area, shall be considered non-hazardous.

2. Where the fuel storage hold spaces include potential leak sources, e.g. tank connections with pipelines and valves, they shall be considered hazardous zone 1.

3. Where the fuel storage hold spaces include bolted access to the tank connection space, they shall be considered hazardous zone 2.

23.2.4 Zone 2:

- area within 1,5 m surrounding open or semi-enclosed spaces of zone 1;
- space containing bolted hatch to tank connection space.

23.3 Electrical equipment required for ship's propulsion, power generation, manoeuvring, anchorage and mooring, emergency fire pumps shall not be located within spaces separated from hazardous zones by air locks or shall be of a certified safe type.

24 SPECIAL REQUIREMENTS FOR VALVE-TYPE GENERATOR SETS

24.1 GENERAL

24.1.1 Unless otherwise specified in this Section, drive movers of valve-type generator sets shall comply with the requirements of Part IX "Machinery", generators and semiconductor converters - with the requirements of this Part and control system - with Part XV "Automation".

The manufacturer shall take into consideration the nature of physical processes in the equipment being part of valve-type generator sets and shall ensure its compatibility and system integration.

24.1.2 Alternating and direct current valve-type generator sets may be used as the main electrical power source. As an emergency electrical power source, the valve-type generator sets may be used only in the ship electric power system with electrical power distribution for direct current.

24.1.3 In addition to the list given in **1.4.2**, prior to survey of electrical equipment during the manufacture, the calculations shall be submitted to the Register for consideration to confirm the absence of mechanical resonance across the operating speed variation range of the valve-type generator set from the minimum to the maximum values, or else the near resonance frequencies shall be excluded from the rotational speed control law.

24.2 DEFINITIONS AND EXPLANATIONS

24.2.1 The following definitions and explanations have been adopted in this Section.

Valve-type generator means an equipment system consisting of rotating electric engine, semiconductor converter and control system intended for generation of electrical power as part of the ship electric power system.

Alternating current valve-type generator means the valve-type generator consisting of a rotating electric engine, semiconductor converter (or inverter) and control system intended for generation of alternating electrical power.

Direct current valve-type generator means the valve-type generator consisting of a rotating electric engine, semiconductor converter (or inverter) and control system intended for generation of direct current electrical power.

Valve-type generator set means a unit consisting of the valve-type generator and prime (drive) heat mover.

Voltage regulator of semiconductor converter means a device being a part of the semiconductor converter of the alternating or direct current valve-type generator set intended for voltage control.

Voltage frequency regulator of semiconductor converter means a device being a part of the semiconductor converter of the alternating current valve-type generator set intended for output voltage frequency control.

24.3 DRIVE (PRIME) MOVERS

24.3.1 Internal combustion engine, steam turbine, gas-turbine engine or other source of mechanical energy, accepted for application on board the ships by these Rules, may be used as a prime mover in the valve-type generator set.

24.4 GENERATORS

24.4.1 Synchronous generator with electromagnetic excitation, synchronous generator with permanent magnets, asynchronous generator, direct current commutator-type generator or other type of electric machines, accepted for application on board the ships by these Rules, may be used as an electrical generator in the valve-type generator set.

24.4.2 generator being a part of the valve-type generator set shall be calculated for the estimated level of higher harmonic components induced by operation for the semiconductor converter. When calculating the rated power of the generator of the valve-type generator set, the sufficient output reserve shall be provided to prevent the generator temperature rise, compared with sinusoidal load.

24.4.3 As regards the valve-type generator set based on the synchronous generators with permanent magnets not capable of field suppression the measures shall be provided for rapid deceleration of the generator shaft in case of inner short circuits in the generator or semiconductor converter, or other additional measures for field suppression or emergency localization shall be provided.

24.5 SEMICONDUCTOR CONVERTERS

24.5.1 Semiconductor rectifiers, inverters, frequency converters, d.c. converters may be used as a semiconductor converter in the valve-type generator set.

24.5.2 Where necessary, the valve-type generator set shall contain the required devices (noise limiters) limiting the distortion level of the generating voltage curve to ensure compliance with the requirements of **2.2.1.3**.

24.5.3 Where necessary, the valve-type generator set shall contain the required devices (noise limiters) limiting the distortion level of the generating voltage curve to ensure compliance with the requirements of.

24.5.4 Direct current valve-type generator set intended for operation as a part of the ship electric power system with electrical power distribution for direct current shall also comply with the requirements of Section **22**.

24.6 COOLING AND LUBRICATING SYSTEMS

24.6.1 For calculating the cooling and lubricating systems of drive movers and generators of the valvetype generator set, decrease of cooling medium and lubricant feed from the appurtenant machinery at the reduction of rotation speed as compared with the rated one shall be considered.

24.7 VOLTAGE REGULATION

24.7.1 The valve-type generator set shall contain a generator voltage regulator and/or semiconductor converter voltage regulator.

24.7.2 On changing of the prime mover rotation speed in accordance with the accepted algorithms, the generator voltage regulator and/or semiconductor converter voltage regulator shall ensure the regulation performance of the output voltage of the valve-type generator set complying the requirements of **10.6** and **10.7**.

24.8 SPEED REGULATION

24.8.1 Drive mover of the valve-type generator set shall be fitted with speed limiter. The requirements for the speed limiter of the prime mover shall be specified by the manufacturer of the valve-type generator set based on the accepted algorithms of speed regulation.

24.9 VOLTAGE FREQUENCY REGULATION

24.9.1 Semiconductor frequency converter being a part of the alternating current valve-type generator set shall be fitted with a frequency regulator that shall ensure regulation performance of the output frequency of the valve-type generator set in compliance with the requirements of **2.11.3**, Part IX "Machinery".

24.10 PROTECTIVE DEVICES

24.10.1 For valve-type generator set, at least the following protective devices shall be provided.

For generator:

from overloads;

from short circuits;

from inner short circuits for generators with the power output of 1000 kVA.

For semiconductor converter:

from minimum input voltage;

from maximum input voltage;

from maximum voltage in direct current link (if present);

from power modules overheating;

overloads;

from inner short circuits;

from an output short circuit.

24.10.2 Valve-type generator sets shall withstand short circuits at the switchboard busbars undamaged. At the short circuit in the ship power mains the valve-type generator (synchronous condenser) shall ensure the short circuit current value sufficient for the activation of protective devices, or else other technical measures ensuring the activation of such devices shall be provided.

24.11 OVERLOAD

24.11.1 All power elements of a valve-type generator set, including generators and semiconductor converters, shall have the overload capacity complying with the requirements of **10.5**.

24.12 SYNCHRONIZATION

24.12.1 Alternating and direct current valve-type generator sets shall be capable of synchronizing and continuously operating in parallel with other generator sets, including those of valve type.

24.12.2 Synchronization of a valve-type generator set shall be ensured by the impact on the voltage regulator of the generator and/or semiconductor converter, and in case of an alternating current valve-type generator set – also by the impact on the voltage frequency regulator of the semiconductor converter.

24.13 POWER DISTRIBUTION WHEN OPERATING IN PARALLEL

24.13.1 When a valve-type generator set operates in parallel with another generator set, including that of a valve type, distribution of active power not in proportion with the rated power output of prime movers is permitted, provided the required ship power mains voltage is ensured, at gradual or abrupt load change and/or variation in the rotational speed of the prime mover.

24.13.2 When a valve-type generator set operates in parallel with another generator set, including that of a valve type, distribution of reactive power not in proportion with the rated power output of prime movers is permitted, provided the required ship power mains voltage is ensured, at gradual or abrupt load change and/or variation in the rotational speed of the prime mover.

24.14 CONNECTION DIAGRAMS AND OPERATION MODES

24.14.1 Bypass circuit connection.

24.14.1.1 Alternating current valve-type generator set with electromagnetic excitation may have a bypass circuit allowing to connect the generator to the switchboard directly, not via a semiconductor converter. In case of bypass circuit connection, the generator set shall operate at a constant rotational speed across the load variation range and comply with the requirements of this Part for power sources operating at a constant speed.

24.14.1.2 Maintaining the constant ship power mains voltage frequency while operating via a bypass circuit is ensured by means of a prime mover speed regulator, maintaining voltage – by means of a generator voltage regulator.

24.14.1.3 Transfer from bypass circuit to semiconductor converter operation (and vice versa) shall be performed while maintaining the connection of the generator set to the switchboard. Disconnection is permitted, provided no overload of other power sources operating at the switchboard busbars is caused.

24.14.2 Motor operation mode.

24.14.2.1 Valve-type generator may operate in the motor mode, if such operation mode is provided for the semiconductor converter, generator and other elements.

24.14.2.2 Motor operation mode is possible for shaft generators either autonomously or together with the main engine for the propeller if fed from other ship power sources.

24.14.2.3 A generator may be used in motor operation mode for the starting of the prime mover of the valve-type generator set using power generated by other mains power sources and then switching into the generator mode. When starting, the parameters of power supply in the ship mains shall comply with the requirements of **2.1.3**. In this case, a compressed starting air system or another main starting method shall be invariably provided for the valve-type generator set.

24.15 MEASUREMENT INSTRUMENTS

24.15.1 For each alternating current valve-type generator the following measurement instruments shall be installed at the switchboard:

.1 an ammeter with a selector switch for generator current measurement in each phase;

.2 an ammeter with a selector switch for converter output current measurement in each phase;

.3 a voltmeter with a selector switch for measurement of generator line voltages;

.4 a voltmeter with a selector switch for measurement of line voltages at the converter output;

.5 a frequency indicator at the generator output;

.6 a frequency indicator at the converter output;

.7 a wattmeter at the generator output;

.8 a wattmeter at the converter output;

.9 a tach-generator.

24.15.2 For each direct current valve-type generator (with an alternating current generator and a semiconductor rectifier) the following measurement instruments shall be installed at the switchboard:

.1 an ammeter with a selector switch for generator current measurement in each phase;

.2 an ammeter with a selector switch for converter output current measurement in each phase;

.3 a voltmeter with a selector switch for measurement of generator line voltages;

.4 a voltmeter for measurement of direct current voltages at the converter output;

.5 a frequency indicator at the generator output;

.6 a wattmeter at the generator output;

.7 a wattmeter at the converter output;

.8 a tach-generator.

25 REQUIREMENTS TO ELECTRICAL EQUIPMENT OF SHIPS INTENDED FOR LONG-TERM OPERATION AT LOW TEMPERATURE

These requirements shall be considered as amendments or additions to the relevant requirements set out in Sections **1 - 19** of this part of the Rules.

25.1 Installation of cables.

25.1.1 Cables to be installed on the open decks and in the open unheated spaces shall be tested at following temperatures:

.1 for ships with distinguishing marks **WINTERIZATION(-30)** at temperature of -40ºC and **WINTERIZATION(-40) -** at temperature of -50ºC;

.2 for ships with distinguishing marks **WINTERIZATION(-50) -** at temperature of -60ºC;

.3 when design ambient temperature is below -50ºC the testing temperature shall be 10ºC lower than the design ambient temperature.

25.1.2 Cable intended for installation on open decks shall have indications in the Register Certificate/Type Approval Certificate whether it is allowed to use it at appropriate temperatures.

25.1.3 Materials for manufacture of cable fastening parts (hangers, cable boxes, pipes) and cable sealing shall meet the requirements of **11**, Part XIII «Materials».

25.1.4 Means shall be provided to protect cable installed on open decks from mechanical damage at manual ice removal.

25.2 Equipment.

25.2.1 All electric motors, switchboards and control panels provided on the open decks and in the open unheated spaces shall be equipped with the means of anticondensation heating.

25.3 Lighting and signal means.

25.3.1 Ships shall be equipped with at least two suitable searchlights which shall be controllable from conning positions.

25.3.2 Searchlights specified in **25.3.1** shall be installed to provide, as far as is practicable, allround illumination suitable for mooring, astern manoeuvres and emergency towing.

25.3.2 Searchlights specified in **25.3.1** shall be designed so as to prevent icing or shall be provided with heating.

25.4 Electrical heating appliances.

25.4.1 Electrical heating fed from emergency sources of electrical power shall be provided for the following ship spaces:

.1 wheelhouse;

.2 radioroom (if any);

.3 main machinery control room;

.4 cargo control room;

.5 fire extinguishing station;

.6 one of public spaces (for instance, messroom);

.7 hospital;

.8 engineering workshop.

25.4.2 Heating appliances capacity fitted in the above spaces shall provide positive temperature in these spaces at design ambient temperature.

25.4.3 Emergency sources of electrical power shall ensure supply of the above heating appliances during the time period stated in **9.3.1**, Part XI "Electrical Equipment".

25.4.4 Battery compartments shall be heated in compliance with the requirements of **13.3**, Part XI "Electrical Equipment". Heating appliances, where fitted, shall be fed from emergency source of electrical power. Thus, it is allowed to perform heating, when power is supplied only from the emergency source of electrical power, by any means in compliance with the international and national standards for explosive atmosphere.

PART XV. AUTOMATION

1. GENERAL

1.1 APPLICATION

1.1.1 The requirements of Sections **1**, **2**, **3**, **7** apply to automation equipment subject to survey irrespective of whether the ship has an automation mark in the class notation or not.

The requirements of Sections **4**, **5**, **6** also apply to ships, which have one of the automation marks added to the character of classification in conformity with **2.2.6**, Part I "Classification".

1.1.2 The present Part contains technical requirements for the automation equipment and ships, in which it is installed and defines the extent of remote automated control, protection, alarming and indication.

1.1.3 Ships with electric propulsion plants and ships with nuclear propulsion plants shall additionally comply with the requirements of Chapter **17.14**, Part XI "Electrical Equipment" of these Rules.

1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of the Rules are given in in Part I "Classification" and General Regulations for the Classification and Other Activity.

For the purpose of the present Part the following definitions have been adopted.

Automated machinery plant is a complex of machinery and equipment fitted up with an automation system.

Uninterruptible power supply is a device supplying output power in some limited time period after loss of main and/or emergency input power with no interruption of the output power. Acknowledgement is a confirmation of receipt of an alarm or call.

Group alarm subsystem is the structural part of the centralized alarm and monitoring system comprising individual additional blocks (panels) wherein some alarms derived from the combining (grouping) of alarms relating to individual machinery and arrangements into one common alarm are concentrated.

The group alarm shall be named after the item to be monitored, e.g. "main engine", "electric power plant", etc.

The group alarm blocks are arranged in accommodation, service and other spaces where the responsible personnel (chief engineer, watch engineers, electrician engineer, etc.) may be present.

Automation device is a part of automation system comprising components, which form a structural and functional unity.

Standby power source is a source of electric power independent of the ship main and emergency power sources.

Alarm and monitoring system is equipment for signalling whenever the controlled parameters reach the preset limit values or deviations of machinery and associated systems from normal working ranges occur. Individual alarms may be grouped in common alarms.

Automation system is equipment intended for an automatic and/or automated control, regulation, monitoring, signalling and protection of machinery or systems.

Remote automated control system is equipment intended for control of machinery from a remote control station enabling an automatic execution of intermediate operations for collection and processing of information on the object and making commands to the executive devices realizing the mode of the machinery functioning set up by the operator.

Safety system is equipment to automatically influence, in a specific way, the operation of machinery under control in order to prevent an emergency or limit its consequences.

Indication system is equipment providing information on the values of certain physical parameters and certain conditions in machinery.

FMEA – (Failure Mode and Effects Analysis) methodology for analyzing the consequences of failures and identifying possible system errors and determining the results in order to classify all errors in terms of their criticality to the system in accordance with DSTU IEC 60812 or the relevant IEC standard.

1.3 SCOPE OF SURVEYS

1.3.1 General provisions concerning classification procedure, survey of ships being designed or constructed, manufacture of equipment and items shall be found in Part I "Classification" and General Regulations for the Classification and Other Activity.

1.3.2 Subject to survey during manufacture are automation components, apparatus and control devices of the following:

.1 main machinery and propellers;

.2 electric power plants;

.3 auxiliary machinery;

.4 main and auxiliary boilers;

.5 refrigerating plants;

.6 alarm and monitoring systems;

.7 safety devices;

.8 other systems as required by the Register.

1.4 TECHNICAL DOCUMENTATION

1.4.1 For the automation equipment listed under **1.3.2**, the technical documentation to be submitted to the Register depending on the object of survey, is as follows:

.1 functional description including technical parameters and operating conditions;

.2 block diagram of control system;

.3 functional process diagram with indication of all instruments and control devices;

.**4** general arrangement and layout;

.**5** user interface description showing the physical layout, a list of all alarms, functions eto allocated each keyboard/screen;

.**6** power supply arrangement and connection diagram;

.**7** cable routing layout diagram;

.**8** instrument and equipment list with indication of performance specifications;

.**9** description of functions covered by software and test program for application software at manufacturer's;

.**10** schematic diagrams of input and output circuits;

.**11** failure mode description;

.**12** test program;

.**13** operation manual;

.**14** installation and maintenance manual.

1.4.2 The technical documentation of equipment shall be submitted to the Register for review prior to ship construction in the scope specified in **4.2.4**, Part I "Classification".

2. DESIGN OF AUTOMATION SYSTEMS, AUTOMATION COMPONENTS AND CONTROL DEVICES

2.1 GENERAL

2.1.1 Reliable operation of automation systems, automation components and control devices shall be ensured under the following ambient temperature conditions:

0 to +45°C in enclosed spaces;

–25 to +45°C on open deck.

Electronic components and devices to be fitted in distribution boards, control panels or enclosures shall reliably operate at ambient temperatures up to +55°C.

No damage to automation systems, automation components and control devices shall be caused by temperatures up to +70°C.

2.1.2 Reliable operation of automation systems shall be ensured at relative air humidity of (75 ± 3)% and temperature of (45 ± 2)°C and temperature of (80 ± 3)% and temperature of (40 ± 2)°C, as well as at relative air humidity of (95 ± 3)% and temperature of (25 ± 2)°C.

2.1.3 Reliable operation of automation systems shall be ensured at vibrations having a frequency of 2 to 100 Hz, namely,

with shift amplitude of ±1 mm where the vibration frequency is between 2 and 13,2 Hz, and

with an acceleration of ±0,7g where the vibration frequency is between 13,2 and 100 Hz.

Reliable operation of automation systems mounted upon vibration sources (diesels, compressors, etc) or installed in steering flats shall be ensured at vibration frequencies of 2 to 100 Hz, namely, with a shift amplitude of ±1,6 mm where the frequency is between 2 and 25 Hz,

and with an acceleration of ±4,0g where the frequency is between 25 and 100 Hz.

2.1.4 Reliable operation of automation systems shall be ensured at long-term heel up to 22,5° and at motions of 22,5° with a period of (8 ± 1)s.

2.1.5 The protection of automation systems, automation components and control devices shall be chosen in accordance with **2.4**, Part XI "Electrical Equipment" proceeding from their location.

2.1.6 Electrical and electronic components and devices shall operate reliably in case of deviation of the power parameters listed in Table 2.1.6 from nominal values.

Table 2.1.6

Parameter	Deviation from nominal value		
	Long-term	Short-term	
	%	%	Time, s
Voltage (a. c.)	+6....–10	±20	1,5
Frequency	±5	±10	5
Voltage (d. c.)	±10	5 10	Cyclic deviation Ripple

Automatic equipment supplied from accumulator batteries shall operate reliably with the following voltage variations from the nominal value:

from +30 to –25% for the equipment, which is not disconnected from the battery during battery charging;

from +20 to –25% for the equipment, which is disconnected from the battery during battery charging.

The operability of automation systems shall not be affected by three successive power supply interruptions during 5 min with switching-off time of 30 s in each case.

2.1.7 Pneumatic and hydraulic components and devices shall be operable under variations of the working medium pressure within ±+20 % of the nominal value.

2.1.8 Provision shall be made to ensure the electromagnetic compatibility of automation equipment as specified in **2.2**, Part XI "Electrical Equipment" and to keep the radio interference from it to a permissible level.

2.1.9 Automation equipment shall operate reliably in case of harmonic distortions of the supply voltage curve as specified under **2.2.1.3**, Part XI "Electrical Equipment".

2.1.10 Components and devices to be installed in locations with specific operating conditions (high or low temperature, excessive mechanical loads, etc) shall be designed and tested with regard to the conditions.

2.1.11 Automation equipment shall be made of materials resistant to marine environment or shall be reliably protected from its harmful effect.

2.1.12 Automation systems shall comprise arrangements to preclude false alarms from momentary changes of parameters due to roll of the ship, machinery switch-on and switch-off, etc.

2.1.13 Automation systems shall be based on the "fail-to-safe" principle.

2.1.14 The list of spare parts for automation equipment and systems is made up by the manufacturer.

For a particular ship, the total number of spare parts is determined on the basis of agreement between the shipbuilder and equipment manufacturer on one part and the shipowner on the other with due regard to the equipment reliability.

2.2 REQUIREMENTS FOR COMPONENTS AND DEVICES

2.2.1 The components and devices of automation systems shall additionally comply with the applicable parts of the Rules.

2.2.2 Replaceable components, which require adjustment, as well as check-up points (terminals, monitoring jacks) shall be so arranged that easy access is possible at any time.

2.2.3 The devices shall be capable of being tested during normal operation.

2.2.4 Equipment shall preferably function without forced cooling. Where such cooling is indispensable, precautions shall be taken to prevent the equipment from being damaged in the event of failure of the cooling unit.

2.2.5 Setting components shall be protected against spontaneous change of setting. Such protection shall not preclude the possibility of adjustment.

2.2.6 Actuators shall be so constructed that no spontaneous change of their setting is possible.

2.2.7 Sensors used for measuring temperature of fire-hazardous, toxic liquids, vapours and gases, liquids, vapours and gases under pressure shall be isolated from the medium tested.

2.2.8 Provision shall be made for checking and calibrating of the pressure transducers at their connections to the test points, without dismantling.

2.2.9 All units, devices and test points shall be clearly and permanently marked. The marking shall be preferably placed adjacent to them.

2.2.10 Electrical and electronic equipment.

2.2.10.1 The contacting connections shall be so designed as to prevent the increase of contact resistance restricting the equipment performance.

2.2.10.2 At cable and wire inlets, especially in way of connections to movable elements and devices, provision shall be made to avoid tension effects.

2.2.10.3 Printed circuit boards shall be coated with insulating varnish.

2.2.10.4 Provision shall be made to prevent incorrect mounting of removable items (modules) having plug-and-socket connections and to ensure their efficient fixing in the working position.

Where necessitated by the operating or structural features of components or devices, their position assuring proper mounting shall be clearly marked or, alternatively, they shall be so constructed that the possibility of being mounted in a wrong position is excluded.

2.2.11 Hydraulic and pneumatic equipment.

2.2.11.1 Hydraulic and pneumatic components and devices shall not be damaged by overloads due to a working medium pressure rise equal to 1,5 times the working pressure.

2.2.11.2 The fluids of hydraulic systems shall retain their physical properties under all possible operating conditions, to possess good lubricating properties and a vapour flash point not less than 60°C, not to cause the damage to components and piping and not to be toxic.

2.2.11.3 Hydraulic automation equipment shall not be connected with other systems and shall be supplied from separate tanks. The use of fluid from other systems may be permitted for actuating systems subject to provision of the relevant filtering arrangements.

2.2.11.4 Connections of the outlet pipes shall be located below the working fluid level in the tanks under any operating conditions of the ship.

2.2.11.5 Pneumatic automation systems shall have arrangements to ensure the required degree of cleanliness and dryness of the air.

2.2.11.6 Pneumatic automation systems of the main propulsion plants and electrical power plants shall generally have two devices for cleaning and drying the air interconnected in such a way that one of them remains operative while the other is cut off.

A single air cleaning and drying device may be permitted where automatic cleaning is provided or its design is such that a rapid replacement of filtering elements is possible without interruption of the air supply.

2.2.11.7 The feeding pipes of pneumatic automation systems shall be fitted up with safety valves set to operate when the nominal working pressure is exceeded by more than 10 %. Reducing valves, if any, shall be duplicated.

2.2.11.8 Where hydraulic, pneumatic and electronic or electric elements and devices are combined in desks, cabinets or cubicles, they shall be effectively separated so that eventual leaks from pipes and hoses and from their connections would not damage such elements and devices.

Desks, cabinets and cubicles accommodating equipment, which contains working fluid, shall be fitted up with appliances for collection and retrieval of the leaks.

2.3 AUTOMATED CONTROL SYSTEMS

2.3.1 Machinery and plants shall be constructed in conformity with the applicable requirements of the relevant parts of the Rules, and equipped with local control stations.

2.3.2 Automated control shall keep all controlled parameters within the limits specified by the normal operating conditions of the machinery and plants under control.

2.3.3 The automated control shall be stable over the entire control range. The margin of stability shall be sufficient to ensure that variations in the controlled parameters that may be expected under normal conditions will not cause instability.

2.3.4 Machinery and plants, which can be started automatically or remotely, shall be fitted up with devices at local control stations to switch off the automatic or remote control, respectively.

In case of automatic or remote control failure, local control is still to be possible.

2.3.5 Changeover from local control mode to automatic or remote control mode shall be possible from local control stations only.

Changeover from remote to automatic control mode may be effected from remote control stations.

2.3.6 If the preset sequence of operations is disturbed, the automated control system shall stop performing the program and shall bring the machinery to a safe condition with an alarm given at all cases at the permanently attended control station.

2.3.7 The starting system of powerful consumers of electrical power, the switching on of which may result in the inadmissible loss of voltage or the main switchboard busbars failure, shall provide for the following:

preliminary automatic start of the standby generator, synchronization, load acceptance and distribution; or

interlocking device preventing the switching on of such consumers prior the standby generator switching to the main switchboard busbars, and the appropriate indication.

2.3.8 In passenger ships, automatic switching devices for auxiliary machinery shall be provided, the redundancy of which is necessary to ensure the propulsion of the ship in accordance with the automation class.

An alarm shall be generated during automatic switch.

2.4 ALARM AND MONITORING, SAFETY, INDICATION AND LOGGING SYSTEMS

2.4.1 Alarm and monitoring system.

2.4.1.1 The alarm and monitoring system shall be independent of control and safety systems, i.e. it shall not be affected by malfunction or failure of such systems.

Partial integration of the alarm and monitoring system with control systems may be allowed for integrated systems provided that the applicable requirements of **7.6.5** including appropriate redundancy.

2.4.1.2 Provision shall be made for the self-monitoring of the alarm and monitoring system; the alarm signal shall be applied in the case of at least such typical faults as short-circuits, open-circuit failure and earth fault, and the failure of the power supply.

2.4.1.3 The alarm and monitoring system shall give visual and audible signals simultaneously. In this case the possibility of simultaneous indication of more than one fault shall be provided. The acknowledgement of one signal shall not prevent the entry of another.

The failure of one component (device) of the system shall not cause failure of the alarm and monitoring system in general. When common monitors are applied instead of individual light signalling devices, at least two such monitors shall be provided.

2.4.1.4 The alarm and monitoring system with its central information panels usually arranged in the main machinery control room shall structurally include the group alarm subsystem, which blocks shall be located:

in spaces between the watertight boundaries, containing main and auxiliary machinery, including boilers, generators and electric propulsion motors (light columns);

on the navigation bridge (in the wheelhouse);

in service and public spaces of a ship; in accommodation spaces of the responsible personnel.

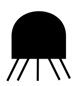
The switching-off of an audible alarm signal on the group alarm blocks (e.g. on the navigation bridge or in accommodation spaces) shall not cause its switching-off in the main machinery control room.

2.4.1.5 In machinery spaces, along with the audible signal devices of the alarm and monitoring system provision shall be made for visual devices (light columns) for the signal identification[1], for which colours and symbols shown in Table 2.4.1.5 shall be used.

See IMO Resolution A.1021 (26) Adoption of the Code on Alarms and Indicators, 2009

Table 2.4.1.5

Function	Signal			
	Sound		Visual: Colour and Symbol	Note
	Device	Code		
1	2	3	4	5

Machinery alarm	Horn Buzzer	3	Yellow 	Horn — in machinery spaces, Buzzer — in other spaces
Machinery alarm	Horn Buzzer	3	Yellow 	Horn — in machinery spaces, Buzzer — in other spaces
Control system alarm	Horn Buzzer	3	Yellow No symbol	Horn — in machinery spaces, Buzzer — in other spaces
Bilge alarm Water level in holds alarm	Horn Buzzer	3	Yellow 	Horn — in machinery spaces, Buzzer — in other spaces
Alarm system malfunction alarm	Horn Buzzer	3	Yellow No symbol	Horn — in machinery spaces, Buzzer — in other spaces
Engineers' alarm	Horn Buzzer	3	Yellow 	Horn/buzzer — in engineers' corridors, buzzer — in engineers' cabins
Engine Room watch alarm	Horn Buzzer	3	Yellow 	Horn — in machinery spaces, Buzzer — in other spaces
Water ingress signal	Horn Buzzer	2	Yellow 	Emergency alarm on the ingress of water in the cargo holds, ballast tanks and other spaces on bulk carriers and cargo ships with one cargo hold, other than bulk carriers (on the bridge)
Fire detection and fire alarm in spaces other than machinery spaces	Ring Buzzer Horn	2	Red 	
	Ditto	2		Should automatically run by a fire alarm, if no reception acknowledgment signal has been within 2 minutes or less. Horn / bell - in other rooms
	Ditto	2		
Release indication of fixed local application fire extinguishing system	Ditto	2	Red  W	
Gas detection alarm — For chlorine	Siren Horn Ring	2	Red **GAS** **Cl**	
Gas detection alarm — Except chlorine	Buzzer Horn	3	Yellow **GAS** x x x	**XXX** - Gas formula may be indicated
Cargo alarm	Horn Buzzer	3	Yellow No symbol	Horn – in machinery spaces; buzzer – in ME, cargo operations control stations and on the navigating bridge

Watertight doors with power source drive alarm	Horn Buzzer	3	Yellow No symbol	Horn — in machinery spaces, Buzzer — in other spaces
Telephone	Horn Buzzer Ring	3.a	White	Horn / Buzzer — in machinery spaces and in engineer's accomodation corridors; Buzzer/ring – in ME control station, on the navigating bridge and engineers' cabins
Engine-room telegraph	Horn Ring Buzzer	2 3.a	White	Horn / ring — in machinery spaces Buzzer /ring — in ME control station, on the navigating bridge
Note. Signal codes refer to Table 2.4.1.17				

Visual indicators shall be clearly visible and distinguishable either directly or by reflection in all parts of the spaces in which light columns are required, flash in accordance with **2.4.1.7**, be of high luminous intensity.

When visibility and distinctiveness in the space cannot be provided by one light column, several columns shall be installed.

Instead of individual flashing lights a single flash or rotating white light in addition to a permanent individual indication may be used for light columns.

2.4.1.6 In spaces with high ambient noise levels, additional audible and visual (flashing or rotating light) signal devices shall be installed.

2.4.1.7 The visual signals shall indicate the fault condition resulted in alarm operation and are generally to flash. The flashing alarm shall be illuminated for at least 50 % of the cycle and have a pulse frequency in the range of 0,5 and 1,5 Hz.

2.4.1.8 Alarms at workstations shall normally be acknowledged in two steps:

switch-off audible signal and additional visual signal (e.g. rotating light signals, etc) leaving the visual signal on the workstation unchanged;

acknowledgment of the visual alarm on the workstation.

After being accepted, the flashing light shall change to steady condition. Cancelling of a visual signal shall only be possible after the abnormal condition has been corrected.

2.4.1.9 Self-eliminating faults shall be indicated by the alarm and monitoring system in such a way that the signal remains applied until it is accepted.

2.4.1.10 Checking of the alarm and monitoring system shall be possible while machinery in operation.

2.4.1.11 Irrespective of the extent of automation and the monitoring order used for the machinery, the alarm and monitoring system shall give warning signals at:

.1 parameters reaching predetermined limit values;

.2 operation of safety devices;

.3 power failure in the circuits of particular automation systems or start of emergency power sources;

.4 deviation from predetermined values of other parameters or operating conditions as regulated by this Part.

Alarms for machinery faults shall be provided on the panels, from which the machinery is remotely controlled.

2.4.1.12 The alarm and monitoring system shall be so arranged that signals not pertinent to navigation and navigational situation are in the first place relayed to the panels in machinery spaces and main machinery control room, as well as to group alarm device in the accommodation, service and public spaces, in which the members of machinery crew might be staying. Then, if the signals are not acknowledged within a specified period of time (e.g. 2 min), they shall be directed to the navigation bridge.

2.4.1.13 The engineers' alarm referred to in **7.8.1**, Part XI "Electrical Equipment" shall be additionally activated automatically where an alarm for machinery plant is not acknowledged at the place of its destination within a specified period of time to be determined by the ship's size but not exceeding 5 min.

2.4.1.14 The personnel alarm referred to in **7.9.1**, Part XI "Electrical Equipment" shall be additionally activated automatically when the engineer on duty has to attend machinery space in case of a machinery alarm. Acknowledgement of the personnel alarm shall not be possible before the engineer has acknowledged the alarm in the machinery space.

2.4.1.15 Manual blocking of separate alarms shall be clearly indicated at the workstation.

2.4.1.16 Blocking of alarm and safety functions in certain operating modes of machinery (e.g. during start-up) shall be automatically disabled in other modes.

2.4.1.17 The audible signals of the alarm and monitoring system shall be readily distinguishable from audible signals of other systems.

The audible signals shall have a frequency from 200 up to 2500 Hz. Provision may be made for means to adjust the frequency of audible signals within the range specified above.

The waveform of audible signal released by alarm and monitoring system shall correspond to one of the waveforms shown in Table 2.4.1.17. The sound pressure level at a distance of 1 m from the sound source shall be not lower than 75 dB and more than by 10 dB higher than the ambient noise existing during the normal functioning of the equipment with the ship underway under moderate weather conditions.

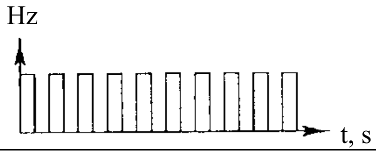
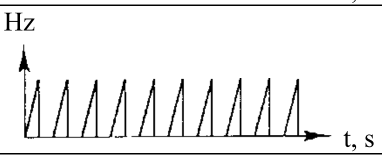
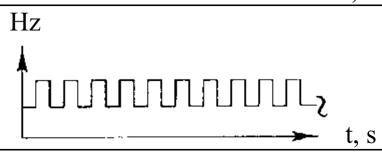
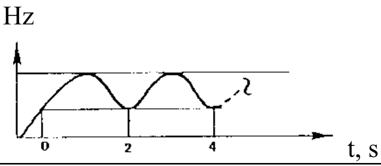
The sound pressure level in a space shall not exceed 120 dB.

The sound pressure level shall be measured within the frequency band of 1/3 octave with respect to the frequency of the first harmonic of the signal.

To ensure that the signal can be properly heard in large spaces and in spaces with high level of ambient noise, several audible signal units shall be installed.

The audible signal of the alarm and monitoring system shall be clearly heard even though one of the signal display units fails.

Table 2.4.1.17 **Waveforms of audible signals of the alarm and monitoring system**

№	**Waveform**	**Note**
1	**2**	**3**
3.a		Optional versions of signal form for differences between signals. Pulse frequency from 0.5 Hz to 2.0
3.b		
3.c		
3.d		

2.4.2 Safety systems.

2.4.2.1 The safety system shall be activated automatically at faults that could involve an emergency condition of machinery or equipment in order to:

.1 restore normal operating conditions (by starting standby units);

.2 temporarily adjust the operation of machinery to the prevailing conditions (e.g. by reducing the load upon the machinery);

.3 protect machinery from emergency condition by stopping the machinery.

Automatic stopping of main machinery shall be executed only in cases of deviation of those parameters, which could lead to serious damage, complete breakdown or explosion.

A safety system shall include an indicator to show the parameter, for which the system was put into operation.

2.4.2.2 The safety systems arranged to shut down the machinery shall be independent of control and alarm systems including sensors so that the faults and failures of those systems including their supply systems would not influence the safety systems.

Where arrangements for overriding the shutdown of machinery are fitted, these shall be such as to preclude inadvertent operation.

Light signal shall be provided on the machinery control panel to indicate when the override has been activated.

2.4.2.3 Provision shall be made for the self-monitoring of the safety systems: at least at such faults as short-circuit, open-circuit failure and earth fault an alarm signal shall be activated.

2.4.2.4 The safety systems of particular machinery and plants shall be independent of each other so that a failure in the safety system of certain machinery or plant would not affect the operability of the safety systems of the rest of the machinery and plants.

2.4.2.5 When the safety system stops the machinery, the machinery shall not start again automatically while the emergency condition is corrected.

2.4.2.6 Provision protection be made within the automatic safety system of the main machinery (propulsion plant) for the alarm to warn of the forthcoming inevitable activation of the safety system for slowdown or shutdown propulsion so that the watch officer has an opportunity and sufficient time to assess navigational situation and in an emergency, if necessary, to counteract the activation of the safety system except for those cases when manual intervention will result in total failure of the main machinery within a short time, for example in the case of overspeed.

2.4.3 Indication and logging systems.

2.4.3.1 Indications sufficient to allow safe operation of essential and important functions shall be installed at all control locations from where the function shall be accomplished. Alarms shall not be considered as substitutes for indications for this purpose.

2.4.3.2 Indication and logging systems shall be independent of any other systems so that their failure would not affect such other systems.

2.4.3.3 When logging systems fail, the alarm signal shall be activated.

2.4.3.4 Provision shall be made for easy reading of indicated data with regard to the illumination at the locations of indicators.

2.4.3.5 Provision shall be made for displaying the readings of indication systems in units normally used for the parameters, i.e. without recalculation.

3. POWER SUPPLY OF AUTOMATION SYSTEMS

3.1 GENERAL

3.1.1 Where automated units shall be supplied from both the main and emergency power sources, the automation systems shall also be supplied from these two power sources independent of each other.

3.1.2 The control systems of main machinery shall be supplied by two separate feeders from separate sections of the main switchboard or from switchboards intended for the power supply of essential services and connected to the separate section of the main switchboard.

If main switchboard busbars are not divided into sections, one of the feeders may be connected to the main switchboard and the other may be connected to the supply switchboard of essential services or to the nearest distribution board. The changeover from one feeder to another shall be effected automatically with appropriate signal activated at the control station**.**

3.1.3 Provision shall be made in the power supply for safety arrangements to allow selective disconnection of failed components.

3.1.4 Where the automation systems of particular auxiliary machinery are supplied by the same feeders as the corresponding electric drives, provision shall be made for a start of standby unit and for connection of the automation system to its feeder in case of a loss of power at the running unit.

3.1.5 Hydraulic and pneumatic automation systems shall be supplied from two sources. The second source shall be connected automatically upon pressure loss with application of an alarm signal.

The use of starting air for automation systems is permitted, provided the air receivers are filled automatically and the requirements of **2.2.11.5** and **2.2.11.6** are complied with.

3.1.6 Alarm and safety systems shall be supplied from an uninterruptible power source, with an alarm being activated upon loss of its input voltage.

The capacity of the accumulator battery of the said power source shall be sufficient for servicing the alarm and safety systems during at least 30 min.

3.1.7 The controls of generator drives shall be supplied independently of the main switchboard busbars.

4. SHIPS WITH AUT1 IN CLASS NOTATION

4.1 GENERAL

4.1.1 Self-propelled ships and floating facilities with the automation mark **AUT1** in class notation shall be equipped with machinery plant automation systems in compliance with the requirements of the Section and to the extent sufficient to ensure their manoeuvrability and safety under all operating conditions without permanent attendance of personnel in machinery spaces and engine control room.

4.1.2 Provision shall be made for an integrated alarm system to cover all the parameters and working conditions under control as mentioned in this Section.

4.1.3 Provisions concerning fire protection shall be found in **4.2.3**, Part VI "Fire Protection".

4.1.4 All equipment installed in machinery spaces shall be capable of operating in an unattended machinery space and main machinery control room. Some operations (replenishment of tanks, cleaning of filters, etc) may be performed manually, if carried out at certain intervals (not more than once every 24 h).

4.2 AUTOMATED MAIN MACHINERY AND PROPELLERS

4.2.1 Provision shall be made for remote automated control system of starting and stopping, as well as of rotational frequency of the main machinery, propeller thrust value and direction within the whole permissible operating range of the propulsion system from the navigation bridge.

4.2.2 Remote automated control system shall meet the following requirements:

.1 automatic attempts, which fail to produce a start, shall be limited so that after the last ineffective attempt the starting air quantity or accumulator battery capacity is sufficient to provide manually a half number of starting attempts as required in **16.1**, Part VIII "Systems and Piping" or **13.7.2**, Part XI "Electrical Equipment";

.2 the last command given shall be executed regardless of the order sequence and quickness;

.3 setting of the thrust value and direction may be effected by means of a single control unit;

.4 an automatic passing of the critical rotational frequency ranges irrespective of the set-operating mode;

.5 overload of the main machinery in the normal operating modes shall be prevented;

.6 remote automated control systems and engine telegraph systems shall be independent of each other (common control lever may be used);

.7 provision shall be made for signalling to indicate power loss and malfunction of the remote automated control system;

.8 impermissible operating modes of the main machinery and propellers (spontaneous increase of rotational frequency, start and reverse) in the event of failure of the remote automated control system shall be precluded;

.9 emergency manoeuvring shall be ensured within the shortest time possible, and along with that, relevant limitations and protections may be removed.

4.2.3 Where there are several control locations, the one in the main machinery control room shall be predominant over the one on the navigation bridge. The same is true in respect of the local control station of the main machinery as compared to the main machinery control room.

4.2.4 The transfer of control from one control location to another shall be possible from a predominant location only, irrespective whether the controls at the locations are matched or not.

The transfer of control shall be accompanied with audible and visual signals at all the control locations.

At the locations, provision shall be made for visual indicators showing from which location control is performed.

4.2.5 The possibility of simultaneous control from different locations shall be eliminated. Use of interconnected controls at one location (e.g. at bridge wings and spaces) may be permissible.

4.2.6 At all the control locations including disconnected ones, provision shall be made for permanent indication of commands transmitted by engine telegraph.

4.2.7 The main engine emergency stop device required by **3.2.1.6**, Part VII "Machinery Installations", if electrically operated, shall be independent of the remote automated control system, alarm and monitoring system and of the ship mains.

4.2.8 In case of main internal combustion engine as a propulsion plants, the temperature of the working media listed below shall be automatically adjust within the prescribed limits:

cylinder coolant;
piston coolant;
nozzle coolant; l
ubricating oil;
fuel oil (if heavy oil is used and viscosity regulation is not available).

As far as main machinery of other types is concerned, the automatic regulation of working medium temperature shall be provided to the extent sufficient to ensure safety operation without permanent attendance of personnel in machinery spaces and engine control room.

4.2.9 With regard to geared diesel plants (two diesels and more), provision shall be made that, with one engine shut down, the others go on running without being overloaded.

4.2.10 Monitored parameters of automated main machinery and propellers, measuring points, limiting values of parameters and types of automatic protection and indication shall be found in Tables 4.2.10-1 – 4.2.10-5.

Tables 4.2.10-1 **Main internal combustion crosshead engines**

№	**Monitored parameter**	**Group 1**: remote indication, alarm, automatic slowdown with alarm	**Group 2:** automatic start of stand-by pumps with alarm	**Group 3:** automatic shutdown of engine with alarm
1	**2**	**3**	**4**	**5**
1	**Fuel oil system**			
1.1	Fuel oil pressure after filter (engine inlet)	● ↓	■	-
1.2	Fuel oil viscosity (temperature) before injection pumps	↑ (↓)	-	-
1.3	Fuel oil leakage from high-pressure pipes	○	-	-
1.4	Fuel oil level in daily service tank [1]	↓	-	-
1.5	Common rail fuel oil pressure	min		
2	**Lubricating oil system**			
2.1	Lubricating oil to main bearing and thrust bearing pressure	● ↓ ▼	■	**X**
2.2	Lubricating oil to crosshead bearing pressure[2]	● ↓ ▼	■	**X**
2.3	Lubricating oil to camshaft pressure[2]	↓	■	**X**
2.4	Lubricating oil to camshaft temperature[2]	↑	-	-
2.5	Lubricating oil inlet temperature	↑	-	-
2.6	Thrust bearing pads temperature or bearing outlet lubricating oil temperature	↑ ▼	-	**X**

2.7	Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main, crank and crosshead bearing oil outlet; or - the engine main, crank and crosshead bearing)[3]	○ ▼	-	-
2.8	Flow rate cylinder lubricator. Each apparatus	↓ ▼	-	-
2.9	Level in lubricating oil tank[4]	↓	-	-
2.10	Common rail servo oil pressure	min		
3	**Turbocharger**			
3.1	Turbocharger lubricating oil inlet pressure[5]	↓	-	-
3.2	Turbocharger lubricating oil outlet temperature of each bearing[6]	↑	-	-
3.3	Rated speed of turbocharger[12]	● ↑	-	-
4	**Piston cooling system**			
4.1	Piston coolant inlet pressure[7]	↓ ▼	■	-
4.2	Piston coolant outlet temperature of each piston	↑ ▼	-	-
4.3	Piston coolant outlet flow of each piston[8]	↓ ▼	-	-
4.4	Piston coolant level in expansion tank	↓	-	-
5	**Sea water cooling system**			
5.1	Sea water pressure	↓	■	-
6	**Cylinder fresh cooling water system**			
6.1	Cylinder water inlet pressure	↓ ▼	■	-
6.2	Cylinder water outlet temperature (from each cylinder) or cylinder water outlet temperature (general)[9]	↑ ▼	-	-
6.3	Oily contamination of engine cooling water system[10]	○	-	-
6.4	Level of cylinder cooling water in expansion tank	↓	-	-
7	**Starting and control air systems**			
7.1	Starting air pressure before main shut-off valve	● ↓	-	-

7.2	Control air pressure	↓	-	-
7.3	Safety air pressure	↓	-	-
8	**Scavenge air system**			
8.1	Scavenge air receiver pressure	●	-	-
8.2	Scavenge air box temperature (fire)	↑ ▼	-	-
8.3	Scavenge air receiver water level	↑	-	-
9	**Exhaust gas system**			
9.1	Exhaust gas temperature after each cylinder	● ↑ ▼	-	-
9.2	Exhaust gas temperature after each cylinder, deviation from average	↑	-	-
9.3	Exhaust gas temperature before each turbocharger	● ↑	-	-
9.4	Exhaust gas temperature after each turbocharger	● ↑	-	-
10	**Fuel valve coolant**			
10.1	Fuel valve coolant pressure	↓	■	-
10.2	Fuel valve coolant temperature	↑	-	-
10.3	Fuel valve coolant level in expansion tank	↓	-	-
11	**Engine speed/direction of rotation**	●	-	-
12	**Wrong way**	○	-	-
13	**Engine overspeed**	-	-	X
14	**Control, safety and alarm systems power supply failure**	○	-	-
15	**Gas concentration in machinery spaces**[11]	↑	-	-

Symbols:

● — remote indication;
↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm signal;

■ — automatic start of stand-by pumps;
▼ — slowdown;
X — engine shutdown.

[1] High level alarm is also required if not suitable overflow arrangement is provided.
[2] If separate lubricating oil systems are installed.
[3] For engines having power more than 2250 kW or a cylinder bore more than 300 mm and dual-fuel engines in accordance with the requirements of **9.5.3**, Part IX "Machinery".
[4] Where separate lubricating oil systems (for camshaft, rocker arms, etc) are installed, individual level alarms shall be provided for each system.
[5] Unless provided with a self-contained lubricating oil system integrated with the turbocharger.
[6] Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.
[7] Slowdown is not required if the coolant is oil taken from the main cooling system of the engine.
[8] Where outlet flow cannot be monitored due to engine design, alternative arrangement may be accepted.
[9] Where one common cooling space without individual stop valves is employed for all cylinder jackets.
[10] Where main engine cooling water is used in fuel and lubricating oil heat exchangers.
[11] Required where installations with dual-fuel (gas _ liquid fuel) engines are used.
[12] Only for turbochargers of Categories B and C (refer to 2.5.7.5, Part IX "Machinery")..

Note: For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown);
for Group 2 parameters - a sensor for automatic start of stand-by pumps;
for Group 3 parameters - a sensor of safety system (engine shutdown).

Table 4.2.10-2 **Main internal combustion trunk piston engines**

№	**Monitored parameter**	**Group 1**: remote indication, alarm, automatic slowdown with alarm	**Group 2:** automatic start of stand-by pumps with alarm	**Group 3:** automatic shutdown of engine with alarm
1	**2**	**3**	**4**	**5**
1	**Fuel oil system**			
1.1	Fuel oil pressure after filter (engine inlet)	● ↓	■	-
1.2	Fuel oil viscosity (temperature) before injection pumps[1]	↑ (↓)	-	-
1.3	Fuel oil leakage from high-pressure pipes	○	-	-
1.4	Fuel oil level in daily service tank[2]	↓	-	-
1.5	Common rail fuel oil pressure	min	-	-
2	**Lubricating oil system**			
2.1	Lubricating oil to main bearing and thrust bearing pressure	● ↓	■	X
2.2	Lubricating oil filter differential pressure	● ↑	-	-

2.3	Lubricating oil inlet temperature	● ↑	-	-
2.4	Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main and crank bearing oil outlet; or - the engine main and crank bearing)[3].	○	-	X
2.5	Flow rate cylinder lubricator. Each apparatus	↓ ▼	-	-
2.6	Common rail servo oil pressure	min	-	-
3	**Turbocharger**			
3.1	Turbocharger lubricating oil inlet pressure[4]	● ↓	-	-
3.2	Turbocharger lubricating oil outlet temperature, each bearing[5]	↑	-	-
3.3	Rated speed of turbocharger[9]	● ↑	-	-
4	**Sea water cooling system**			
4.1	Sea water pressure	● ↓	■	-
5	**Cylinder fresh cooling water system**			
5.1	Cylinder water inlet pressure or flow	● ↓ ▼	■	-
5.2	Cylinder water outlet temperature[6]	● ↑ ▼	-	-
5.3	Level of cylinder cooling water in expansion tank	↓	-	-
6	**Starting air and control air systems**			
6.1	Starting air pressure before main shut-off valve	● ↓	-	-
6.2	Control air pressure	● ↓	-	-
7	**Scavenge air system**			
7.1	Scavenge air receiver temperature	↑	-	-
8	**Exhaust gas system**			
8.1	Exhaust gas temperature after each cylinder[7]	● ↑ ▼	-	-
8.2	Exhaust gas temperature after each cylinder, deviation from average[7]	↑	-	-

9	**Engine speed**	●	-	-
10	**Engine overspeed**	-	-	X
11	**Control, safety and alarm systems power supply failure**	○	-	-
12	**Gas concentration in machinery spaces**[8]	↑	-	-

Symbols:

● — remote indication;

↑ — alarm for high value;

↓ — alarm for low value;

○ — alarm signal;

■ — automatic start of stand-by pumps;

▼ — slowdown;

X — engine shutdown.

1 For heavy fuel oil burning engines only.

2 High level alarm is also required if no suitable overflow arrangement is provided.

3 For engines having power more than 2250 kW or a cylinder bore more than 300 mm and dual-fuel engines in accordance with the requirements of **9.5.2.3**, Part IX "Machinery".
One oil mist detection arrangement (or engine bearing temperature monitoring system or equivalent device) is required for each engine having two independent outputs (for initiating the alarm and shutdown) satisfy the requirements for independence between the alarm and shutdown systems.

4 Unless provided with a self-contained lubricating oil system integrated with the turbocharger.

5 Where outlet temperature from each bearing cannot be monitored due to the engine/turbocharger design alternative arrangements may be accepted. Continuous monitoring of inlet pressure and inlet temperature in combination with specific intervals for bearing inspection in accordance with the turbocharger manufacturer's instructions may be accepted as an alternative.

6 Two separate sensors are required for the alarm and slowdown.

7 For engines with cylinder output of more than 500 kW.

8 Required where installations with dual-fuel (gas - liquid fuel) engines are used.

9 Only for turbochargers of Categories B and C (refer to **2.5.7.5**, Part IX "Machinery").

Note. For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown);

for Group 2 parameters - a sensor for automatic start of stand-by pumps;

for Group 3 parameters - a sensor of safety system (engine shutdown)..

Table 4.2.10-3 **Main steam turbines**

№	**Monitored parameter**	**Group 1:** indication, alarm,	**Group 2:** automatic start of stand-by pumps with alarm	**Group 3:** automatic shutdown of turbine
1	**2**	**3**	**4**	**5**
1	Lubricating oil pressure after oil cooler ла	● ↓	■	X
2	Lubricating oil differential pressure across filter	◗ ↑	-	-
3	Lubricating oil temperature at each bearing outlet	● ↑	-	-
4	Lubricating oil level in gravity tank	◗ ↓	-	X
5	Steam temperature before manoeuvring valves[1]	◗ ↑ ↓	-	-

6	Steam pressure before manoeuvring valves	● ↑	-	-
7	Steam pressure in condenser	● ↑	-	X
8	Pressure in deaerator	◗ ↑ ↓	-	-
9	Water level in deaerator	◗ ↑ ↓	-	-
10	Water level in condenser	◗ ↑ ↓	-	X
11	Water pressure after condensate pump	◗ ↓	■	-
12	Condensate salinity	↑	-	-
13	Turbine vibration	↑	-	X
14	Axial displacement of rotor	↑	-	X
15	Steam pressure in end glands	● ↑	-	-
16	Sea water pressure at circulating pump outlet	● ↓	■	-

Symbols:

● — remote indication (continuous);
◗ — remote indication (on call);
↑ — alarm for high value;
↓ — alarm for low value;
■ — automatic start of stand-by pumps;

X — turbine shutdown
[1] When re-heating is used, an additional alarm is required at turbine inlet

Note. For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown);
for Group 2 parameters - a sensor for automatic start of stand-by pumps;
for Group 3 parameters - a sensor of safety system (turbine shutdown).

***Table 4.2.10-4* Main gas turbines**

№	**Monitored parameter**	**Group 1:** indication, alarm,	**Group 2:** automatic start of stand-by pumps with alarm	**Group 3:** automatic shutdown of gas turbine
1	**2**	**3**	**4**	**5**
1	Lubricating oil pressure at inlet	● ↓	■	**X**
2	Lubricating oil temperature at inlet	◗ ↑	-	-
3	Bearing temperature	◗ ↑	-	-
4	Gas temperature at gas turbine outlet	● ↑	-	**X**
5	Flame failure or ignition system failure or stratification of temperatures over flame tubes	◗ ↑	-	**X**
6	Automatic start system	○	-	-
7	Fuel oil pressure at gas turbine inlet	● ↓	-	**X**[1]
8	Fuel oil pressure before burners	● ↓	-	**X**[1]
9	Fuel oil temperature before burners2	◗ ↑ ↓	-	-
10	Pressure differential across air cleaner	◗ ↑	-	-

11	Gas turbine vibration at each support	◗ ↑	-	X
12	Axial displacement of rotor	↑	-	X
13	Gas turbine speed (at each rotor)	● ↑	-	X[3]
14	Oil level in lubricating oil tank	◗ ↓	-	
15	Automatic gas turbine shutdown	○	-	-
16	Gas pollution of machinery room	● ↑	-	X[1]
17	Temperature under sheath	● ↑	-	-
18	Gas temperature after gas turbine	◗ ↑	-	-
19	Failure of power supply to control, alarm and safety systems	○	-	-

Symbols:

● — remote indication (continuous);
◗ — remote indication (on call);
↑ — alarm for high value;
↓ — alarm for high value;
■ — automatic start of stand-by pumps;
○ — signal alarm;
X — turbine shutdown.

[1] When gas is used.
[2] When high-viscosity fuels are used.
[3] Shutdown resulted from power turbine speed.

Note. For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown);

for Group 2 parameters - a sensor for automatic start of stand-by pumps;

for Group 3 parameters - a sensor of safety system (turbine shutdown).

Table 4.2.10-5 **Shafting, CPP, reduction gear and couplings**

№	**Monitored parameter**	**Group 1:** indication, automatic slowdown	**Group 3:** automatic shutdown of engine (turbine)
1	**2**	**3**	**4**
1	**Shafting**		
1.1	Temperature of thrust bearing (or lubricating oil), including those built in engine and reduction gear	↑ ▼	X
1.2	Temperature of shaft bearings (or lubricating oil)	↑	-
1.3	Temperature of sterntube bearing (or lubricating oil)[1]	↑	-
1.4	Lubricating oil level in sterntube lubricating tank[2]	↓	-
1.5	Water flow at sterntube inlet[3]	↓	-
2	**CPP**		
2.1	Hydraulic oil pressure at outlet of filter	↓	-
2.2	Hydraulic oil level in sterntube oil lubricating tank	↓	-
2.3	Loss of auxiliary power (power supply to controls)4	○	-
3	**Reduction gears and couplings**		
3.1	Lubricating oil pressure at reduction gear inlet[5]	● ↓	X
3.2	Lubricating oil temperature in reduction gear	◗ ↑ ▼	-
3.3	Temperature of each sliding bearing[6]	↑	-
3.4	Hydraulic oil pressure at coupling inlet	● ↓	-

Symbols:

●	— remote indication (continuous);
↑	— alarm for high value;
↓	— alarm for high value;
■	— automatic start of stand-by pumps;
○	— signal alarm;
X	— turbine shutdown.
◗	— remote indication (on call);

[1] Refer to 5.6.3, Part VII "Machinery Installations".
[2] With closed sterntube.
[3] When water lubrication is used.
[4] Indication at navigation bridge.
[5] Where a coupling is fitted, disengagement of coupling may be effected instead of engine shutdown.
[6] For engines having power of more than 2250 kW.
Note. For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown);
for Group 3 parameters - a sensor of safety system (engine (turbine) shutdown).

4.3 AUTOMATED BOILER PLANTS

4.3.1 The requirements of this Chapter cover boiler plants with oil-burning installations, waste-heat boilers and composite boilers, as well as combinations of such boilers forming part of the ship's machinery plants.

4.3.2 When two or more boilers fitted on board feed a common steam main, provision shall be made for automatic control of each boiler singly operating under load, where such operation is provided by the design, keeping the standby boilers in readiness and putting the boilers under load, parallel operation of boilers and securing all steam.

Automatic transfer from one operating mode to another shall not initiate operation of the safety valves, alarms to indicate steam pressure and water level in boilers and in hot well (deaerator) of steam boiler plants, and in case of thermal fluid boilers, alarm to indicate the fluid temperature after the boilers and before the consumers, as well as the alarm to indicate the level in the expansion tank.

4.3.3 In waste-heat boilers the transfer of the evaporative mode to the water-heating mode and viceversa shall not initiate operation of the safety valves, alarms to indicate steam pressure and water level in boilers and in hot well, as well as the necessity of the additional feed water.

4.3.4 Steam pressure and thermal fluid temperature shall be regulated automatically. Besides, the steam boilers shall be provided with automatic feed water regulators.

The waste-heat boilers may have no automatic steam pressure and thermal fluid temperature regulation, if alternative arrangements are provided to stabilize the said parameters.

4.3.5 Steam boilers shall have at least two low water level detectors independent of each other and connected to different output devices. The lower one shall be used solely for no-water protection.

The second detector may also be used for shutdown in case of low water levels, or for alarm and feed water regulating systems.

The above requirement does not apply to forced-circulation boilers, waste-heat boilers, the design of which allows operation without water, and to the secondary system headers of double-pressure boilers.

4.3.6 Provision shall be made for a remote shutdown of the burning boilers and closing of dampers in wasteheat boilers allowing no "dry" operation, from the control station where continuous watch is kept.

4.3.7 Automated oil-burning boilers shall be fitted up with interlocking devices to permit fuel oil being fed into the boiler furnace during firing-up, when the requirements listed below are complied with in addition to those of **5.3.2**, Part X "Boilers, Heat Exchangers and Pressure Vessels":

.1 fuel temperature (viscosity) is such that adequate atomisation is assured;

.2 pressure of steam or air for atomisation is within the normal range.

4.3.8 Automated oil-burning boilers shall be equipped with protective devices in accordance with the requirements of **5.3.3**, Part X "Boilers, Heat Exchangers and Pressure Vessels".

4.3.9 Starting of boiler plants from cold condition and after being shut down by the protection system and if the ignition of oil fuel fails shall be possible from the local control station only.

4.3.10 Boilers with inherent in air supply casing and supply ducts and in flue gas uptake and ducts shall be provided with alarms to indicate fire outbreak in accordance with the requirements of **4.4.5**, Part X "Boilers, Heat Exchangers and Pressure Vessels". Position of detectors shall be selected depending on the design features of boilers.

4.3.11 Monitored parameters of automated boiler plants, measuring points, limited parameter values and types of automatic protection and indication shall be found in Table 4.3.11.

Table 4.3.11 **Automated boiler plants**

№	**Monitored parameter**	**Indication, alarm**	**Automatic protection**
1	**2**	**3**	**4**
1	**Main steam boilers and essential auxiliary steam boilers, waste-heat boilers and alternately fired boilers**		
1.1	Steam pressure in boiler drum (at super-heater outlet)[1]	● ↑ ↓	-
1.2	Steam temperature at super-heater outlet	● ↑	-
1.3	Steam temperature at steam cooler outlet	● ↑	-
1.4	Water level in boiler drum	↑ [2] ↓	X[3]
1.5	Feed water pressure or pressure differential[4]	● ↓	-
1.6	Stoppage of circulation in forced-circulation boilers	○	X
1.7	Water level in steam separator	↓	-
1.8	Water level in hot well	↓	-
2	**Automatic oil-burning installations**		
2.1	Fuel oil pressure at burner inlet[4]	↓	-
2.2	Atomization air or steam pressure	↓	-
2.3	Fuel oil temperature at burner inlet[5]	● ↓	-
2.4	Air pressure before oil-burning installation[6]	↓	X
2.5	Flame failure	○	X
3	**Thermal liquid boilers and boiler plants**		
3.1	Thermal liquid temperature at boiler outlet	↑	X
3.2	Thermal liquid flow at boiler outlet	↓	X
3.3	Thermal liquid level in expansion tank	↑ ↓	X[3] ■[3]
3.4	Thermal liquid leakage in the furnace of the auxiliary boiler	○	X ■
3.5	Thermal liquid leakage in the drain chamber of the waste-heat boiler	○	X ■
3.6	Increase of gas temperature in the flue duct of the auxiliary boiler	○	X ■
3.7	Increase of gas temperature in the flue duct of the waste-heat boiler	○	X ■

Symbols:

● — remote indication (continuous);
↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm signal;
■ — circulating pump shutdown;
X — shutdown (stoppage of heat application).

[1] For auxiliary boilers, alarm may be provided in the main steam line only. [2] Only for boilers to power machinery. [3] Only after parameter reaches low value. [4]For main boilers only. [5] For heavy oil burning installations. [6] May be dispensed with, where the forced-draft fan and fuel oil pump are directly driven by a single prime mover.

4.4 AUTOMATED ELECTRIC POWER PLANTS

4.4.1 Automated electric power plants shall ensure remote starting of generator sets with automatic synchronization, taking over and load sharing.

4.4.2 Besides compliance with the requirements of **3.1.3**, Part XI "Electrical Equipment", in order to ensure continuous power supply on board ships where electrical power is normally supplied from one generator, control devices shall be provided to ensure automatic starting of standby generator, automatic synchronization, taking over and distribution of load in cases where:

maximum permissible load is reached by the generator during operation;

there is malfunction of the operating unit, which enables an automatic synchronization of generators to be carried out.

4.4.3 Indicators shall be provided at relevant control stations to warn that the generator sets are ready to start immediately (automatically).

4.4.4 Provision shall be made for preliminary determination of sequence, in which the generators shall be started automatically and connected to the busbars of the main switchboard.

4.4.5 If the shaft-generator rotational speed or inlet steam pressure of exhaust gas steam turbinegenerator is lowered so that the working parameters as stated under **2.11.3**, Part IX "Machinery", as well as **10.6.2** and **10.7.2**, Part XI "Electrical Equipment" cannot be achieved, at least one independently driven generator shall be automatically started to ensure compliance with provision of **4.4.2**.

4.4.6 Monitored parameters of automatic electric power plants (except emergency), measuring points, limiting values of parameters and types of automatic protection and parameter indication shall be found in Tables 4.4.6-1 – 4.4.6-3.

Tables 4.4.6-1 **Automated ship electric power plants**

№	Monitored parameter	Indication, alarm	Automatic protection
1	**Ship mains**		
1.1	Voltage	● ↓	**X**
1.2	Current frequency	● ↓	-
1.3	Insulation resistance	↓	-
2	**Generators**		
2.1	Load (current)	● ↑	▼ **X**
2.2	Reverse power (current)	↑	**X**
2.3	Winding temperature[1]	↑	-
Symbols:			
●	— remote indication (continuous);		
↑	— alarm for high value;		
↓	— alarm for low value;		
▼	— disconnection of non-essential consumers;		
X	— disconnection of generator. Effected by the protection system of the generators (refer to 8.2, Part XI "Electrical Equipment").		
[1] Required only for a.c. generators having output of more than 5000 kW or axial length of active steel more than 1000 mm.			

Table 4.4.6-2 **Internal combustion trunk piston engines for driving generators**

№ з/п	Monitored parameter	Alarm	Automatic shutdown of engine with alarm
1	2	3	4
1	Fuel oil leakage from high-pressure piping	○	-
2	Lubricating oil temperature	↑	-
3	Lubricating oil pressure	↓	X
4	Activation of oil mist detection arrangements (or activation of the temperature monitoring systems or equivalent devices of: - the engine main and crank bearing oil outlet; or - the engine main and crank bearing)[1]	↑	X
5	Cooling water pressure or flow	↓	-
6	Cooling water or air temperature	↑	-
7	Cooling water level in expansion tank2	↓	-
8	Fuel oil level in daily tank	↓	-
9	Starting air pressure	↓	-
10	Overspeed	-	X
11	Fuel oil viscosity (temperature) at inlet of high-pressure pumps[3]	↑ (↓)	-
12	Exhaust gas temperature at each cylinder outlet[4]	↑	-
13	Gas concentration in machinery spaces[5]	↑	-
14	Common rail fuel oil pressure	min	-
15	Common rail servo oil pressure	min	-
16	Rated speed of turbocharger[6]	↑	-

Symbols:

↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm signal;
X — engine shutdown.

[1] For engines having power more than 2250 kW or a cylinder bore more than 300 mm and dual-fuel engines in accordance with the requirements of **9.5.2.3**, Part IX "Machinery". One oil mist detection arrangement (or engine bearing temperature monitoring system or equivalent device) is required for each engine having two independent outputs (for initiating the alarm and shutdown) satisfy the requirements for independence between the alarm and shutdown systems.
[2] If separate cooling system provided.
[3] When working on heavy fuel.
[4] For engines with cylinder output more than 500 kW.
[5] Required where installations with dual-fuel (gas - liquid fuel) engines are used.
[6] Only for turbochargers of Categories B and C (refer to **2.5.7.5**, Part IX "Machinery").

Table 4.4.6-3 **Steam turbines driving generators**

№	**Monitored parameter**	**Indication, alarm**	**Automatic shutdown of turbine**
1	**2**	**3**	**4**
1	Lubricating oil pressure at oil cooler outlet	◗ ↓	**X**
2	Lubricating oil temperature at bearing outlets	◗ ↑	-
3	Steam pressure in condenser	◗ ↑	**X**
4	Steam pressure before turbine	◗ ↓	-
5	Water level in condenser	↑	-
Symbols:			
◗ — remote indication (on call); ↑ — alarm for high value; ↓ — alarm for low value;			
X — alarm for high value.			

4.5 AUTOMATED COMPRESSOR PLANTS

4.5.1 Compressed air systems shall be fitted up with arrangements for automatic removal (blow out) of water and oil.

4.5.2 The automated compressor plants shall be capable of operating manually from the local and remote control stations and automatically.

In automatic mode of operation, the compressors shall keep up nominal pressure of compressed air in the air receivers so that:

.1 when the air pressure drops to the preset value, for example, to 90 %, the preselected compressor shall be automatically started and automatically shut down once the air pressure have reached a value equal to the nominal one;

.2 in case of an intensive air consumption and further drop of air pressure, for example, to 80 %, a second compressor turned on automatic mode shall be automatically started, and both compressors shall keep operating until the nominal pressure is attained.

4.5.3 Monitored parameters of automated compressor plants, measuring points, limiting values of parameters and types of automatic protection and indication shall be found in Table 4.5.3.

Table 4.5.3 **Automated compressor plants**

№	**Monitored parameter**	**Indication, alarm**	**Automatic protection**
1	Lubricating oil pressure at compressor inlet	↓	**X**
2	Coolant flow at compressor outlet[1]	↓	**X**
3	Air temperature at cooler outlet	↑	-
4	Starting air pressure at air receiver outlet	● ↓	-
5	Control air pressure	↓	-
Symbols: ● — remote indication; ↑ — alarm for high value; ↓ — alarm for low value; **X** — compressor shutdown. [1] Instead of flow, maximum coolant temperature may be monitored.			

4.6 AUTOMATED PUMPING UNITS

4.6.1 Automated pump control system shall ensure automatic starting of standby pumps and changeover as necessary in plants in case of pump failure or upon reaching the highest permissible deviations of parameters in essential plants. The faulty pump shall be stopped and an alarm given only after the standby pump has been started.

4.6.2 The electric circuit of pumps having equal output shall make it possible to use each of them as the main pump.

This requirement does not apply to attached pumps.

4.7 AUTOMATED BILGE PUMPING OF MACHINERY SPACES

4.7.1 Depending on the water level in the bilge wells, the bilge wells in machinery spaces shall be drained either automatically or remotely. Indication for pump operation shall be provided.

4.7.2 If, after the bilge pumps have been started, they do not come to stop within a specified period of time, that is, the water in the bilge wells does not fall, an alarm shall be given.

4.7.3 A separate sensor shall be provided to signal the highest permissible level, which would be independent of the sensors fitted to control the bilge pumps.

4.7.4 Monitored parameters of automated bilge plants, measuring points and limiting values of parameters shall be found in Table 4.7.4.

4.7.5 In automated bilge pumping of machinery spaces, special attention shall be paid to the requirements for the prevention of oil pollution.

Table 4.7.4 **Automated bilge plants of machinery spaces**

№	Monitored parameter	Alarm
1	Water level in bilge wells	↑ ↓ [1]
2	Emergency water level in bilge wells and shaft passages[2]	↑

Symbols:

↑ — alarm for high value;
↓ — alarm for low value;

[1] When remotely controlled.
[2] Alarm signal is brought out to the wheelhouse

4.8 AUTOMATED REFRIGERATING PLANTS

4.8.1 In accordance with **1.1**, Part XII "Refrigerating Plants", automated refrigerating plants shall comply with the requirements of **7.2** of the same Part, as well as to provide automatic maintenance of temperature in the refrigerated spaces.

4.8.2 Provision shall be made for indication of the automated refrigerating plant operation and for alarm of its malfunction.

4.8.3 Monitored parameters of automated refrigerating plants, measuring points, limiting values of parameters and types of protection shall be found in Table 4.8.3

Table 4.8.3 **Automated refrigerating plants**

№	Monitored parameter	Alarm	Automatic protection
1	**2**	**3**	**4**
1	**Driving motors**		
1.1	Motor load (current)	↑	▼
2	**Compressors**		
2.1	Suction pressure	↓	**X**
2.2	Discharge pressure[1]	↑	**X**
2.3	Discharge temperature	↑	**X**
2.4	Lubricating oil pressure or flow	↓	**X**
2.5	Lubricating oil temperature	↑	**X**
2.6	Rotor displacement[2]	↑	**X**

2.7	Bearing temperature[2]	↑	**X**
3	**Pressure vessels, heat exchangers, refrigerant, secondary refrigerant, cooling water pumps**		
3.1	Refrigerant flow in pump	↓	□
3.2	Secondary refrigerant flow in evaporator	↓	**X**[3]
3.3	Cooling water discharge pressure or flow in discharge pipeline	↓	**X**
3.4	Refrigerant level in circulation receivers, liquid separators, intermediate vessels, level type evaporators[4]	↑	**X**
3.5	Secondary refrigerant temperature at evaporator outlet	↓	**X**[3]
3.6	Secondary refrigerant level in expansion tank	↑ ↓	**-**
4	**Spaces with controlled atmosphere, atmosphere control arrangements**		
4.1	Air temperature in refrigerated cargo spaces	↑ ↓	**-**
4.2	Stopping of air cooler ventilator for refrigerated cargo space[5]	○	**-**
4.3	Refrigerant concentration in air of spaces with equipment under refrigerant pressure[6]	↑	■
4.4	CO2, O2, N2 concentration in refrigerated cargo spaces[7]	↑ ↓	**-**
4.5	Relative air humidity in refrigerated cargo spaces[7]	↑ ↓	**-**

Symbols:

○ — alarm signal;
↑ — alarm for high value;
↓ — alarm for low value;
▼ — engine shutdown;
□ — pump stop;
■ — switching-on of emergency ventilation, except emergency ventilation of refrigerated cargo spaces, for switching-on of which it is necessary previously to render the air duct shut-off devices operativy;
X — compressor shutdown.

[1] In case of piston two-stage compressors, for each stage.
[2] For centrifugal compressors.
[3] Or stopping the delivery of refrigerant into evaporator.
[4] Compressor shutdown when the level is maximum. In case of liquid separators performing only protective functions, the refrigerant level indication may be dispensed with.
[5] For each ventilator.
[6] Separate alarm on the navigation bridge.
[7] Where applicable: for systems with atmosphere control, for carriage of fruits and vegetables.

4.9 EQUIPMENT ARRANGEMENT ON THE BRIDGE

4.9.1 Provision shall be made for a control station to effect-automated remote control of main machinery and/or propellers in conformity with **3.2**, Part VII "Machinery Installations".

4.9.2 An alarm device shall be fitted to give group or individual signals of malfunctions of machinery installation, including those that require immediate shutdown of the main machinery and those that require reduction of the main machinery power.

In this case a system of alarms included in common alarm shall be provided separately at main control stations or, alternatively, at local control stations.

In the latter case, a master alarm display shall be provided at the main control station showing which of the local control stations is indicating a fault condition.

4.9.3 On the bridge, provision shall be made for the following separate alarms:

"Water in machinery space";

"Fire in machinery space";

"Aalarm system failure";

as well as separate alarm "High gas concentration in machinery space", if the ship is provided with main and/or auxiliary dual-fuel (gas - liquid fuel) engines.

4.9.4 Provision shall be made for visual signalling (indication) in case of signals required by **4.9.2** and **4.9.3** being acknowledged in the machinery space.

4.9.5 Provision shall be made for remote control bilge system wells of machinery spaces, where no provision is made for an automated bilge system in compliance with **4.7.1.**

4.10 EQUIPMENT ARRANGEMENT IN MACHINERY SPACES

4.10.1 Provision shall be made in the vicinity of the local control station for alarms and indicators of parameters as required by **4.2 – 4.8**.

4.10.2 The controls of auxiliaries (pumps, separators, boiler plants, generator prime movers) are recommended to be installed in close proximity to the local control station of the main machinery.

4.10.3 Main machinery control room, if provided, shall be fitted up with the following:

.1 devices required by **3.2**, Part VII "Machinery Installations";

.2 alarm panel;

.3 devices to indicate the operating modes of machinery and plants;

.4 disconnecting devices of the oil-burning installations of boilers, incinerators, ventilators of machinery spaces, separators fuel oil and lubricating oil pumps.

.5 remote controls of bilge wells for drainage in machinery spaces, where no provision is made for an automated bilge system in compliance with **4.7.1**.

4.10.4 Where there is an enclosed main machinery control room, a device shall be fitted therein to call personnel from the machinery spaces.

4.10.5 At the main machinery control room, the following separate signals shall be provided:

"Water in machinery space";

"Fire in machinery space";

as well as separate alarm "Limiting gas concentration level in machinery space", if the ship is provided with main and/or auxiliary dual-fuel (gas - liquid fuel) engines.

4.11 DEVICES IN ENGINEERS' ACCOMMODATION

4.11.1 In engineers' cabins, public spaces, as well as in spaces where watch is kept while in port, group alarm devices shall be fitted to warn of the malfunctions of machinery and plants, as well as signal devices in accordance with **4.9.3** of this Section and **3.8.3.9**, Part VI "Fire Protection".

The acknowledgement of each signal from these devices shall cancel the audible signal only.

4.11.2 Where there are several cabins a switch for the devices mentioned in **4.11.1** may be provided to select the responsibility (watch keeper). The remaining cabin devices are disconnected in this case.

5. SHIPS WITH AUT2 IN CLASS NOTATION

5.1 GENERAL

5.1.1 Ships and floating facilities with the automation mark **AUT2** in class notation shall be equipped with machinery plant automation systems to the extent sufficient to ensure the manoeuvrability and safety of selfpropelled ships or the safety of non-self-propelled ships under all operating conditions without permanent attendance of personnel in machinery spaces, but if watch is kept at the main machinery control room.

5.1.2 Unless otherwise provided hereafter, the requirements of Section **4**, except for **4.11**, shall be complied with.

5.1.3 Provision shall be made for automation of main machinery and propellers in accordance with the applicable requirements of **4.2**.

5.1.4 An alarm system shall be provided for all applicable parameters and working conditions mentioned in Section **4**.

5.1.5 All equipment installed in machinery spaces shall be capable of operating in an unattended machinery space. Some operations (replenishment of tanks, cleaning of filters, etc) may be performed manually, if carried out at certain intervals (not more than once every 12 h).

5.2 EQUIPMENT ARRANGEMENT ON THE BRIDGE

5.2.1 Provision shall be made for remote automated control of the main machinery and/or propellers from the navigation bridge.

5.2.2 Remote automated control of the main machinery and/or propellers from the navigation bridge shall include:

.1 equipment as required by **3.2**, Part VII "Machinery Installations" shall be fitted;

.2 alarm, which would enable to identify the reason of failure that requires slowdown and/or shutdown of the main machinery.

5.3 EQUIPMENT ARRANGEMENT IN MACHINERY SPACES

5.3.1 Provision shall be made for an enclosed main machinery control room fitted out in conformity with **4.10.3** and, additionally, with remote controls of essential auxiliaries if the latter are not automated.

5.3.2 Provision shall be made for the call and signal devices as stipulated by **4.10.4** and **4.10.5**.

5.4 ELECTRIC POWER PLANTS

5.4.1 Besides compliance with the requirements of 3.1.3, Part XI "Electrical Equipment", where no provision is made for an automated electric power plant in conformity with **4.4**, the following shall be available:

remote start and shutdown of generator prime movers from the main machinery control room;

remote synchronizing, switching on and load sharing from the main machinery control room.

These operations may be effected from the main switchboard if installed at the main machinery control room.

5.5 BILGE SYSTEMS OF MACHINERY SPACES

5.5.1 Where no provision is made for an automated bilge system in conformity with **4.7**, bilge wells in machinery spaces shall be remotely drained from the main machinery control room.

5.5.2 Alarm shall be provided in conformity with **4.7.4**.

6. SHIPS WITH AUT3 IN CLASS NOTATION

6.1 GENERAL

6.1.1 Ships and floating structures with the automation mark **AUT3** in class notation, the main machinery of which have the power up to 2250 kW, shall be fitted with machinery installation automation systems to the extent, by which their manoeuvrability and safety would be ensured without permanent attendance of personnel in machinery spaces and main machinery control room (as far as non-selfpropelled ships are concerned, the above power is the power of the prime movers of generators, which ensure that the main purpose of the ship is fulfilled).

6.1.2 Unless otherwise provided hereafter, the requirements of Section **4** shall be complied with.

6.1.3 Monitored parameters of machinery and plants, measuring points, limiting values of parameters and types of automatic protection and parameter indication shall be found in Table 6.1.3.

Table 6.1.3

№	**Monitored parameter**	**Group 1:** indication, alarm, automatic slowdown	**Group 2:** automatic start of stand-by pumps with alarm[1]	**Group 3:** automatic shutdown of engine
1	**2**	**3**	**4**	**5**
1	**Main internal combustion engines**			
1.1	Lubricating oil pressure at engine inlet	● ↓	■	X
1.2	Lubricating oil temperature at engine inlet	● ↑	-	-
1.3	Lubricating oil flow at lubricator outlet	↓ ▼[2]	-	-
1.4	Lubricating oil pressure differential across filter	◗ ↑	-	-
1.5	Turbocharger lubricating oil pressure at bearing inlet3	↓	-	-
1.6	Oil mist concentration or bearing temperature at each crank or bearing	↑ ▼[2, 4]	-	X[5]
1.7	Coolant pressure or flow at engine inlet	● ↓ ▼[2]	■	-
1.8	Coolant temperature at engine outlet	◗ ↑ ▼[2]	-	-
1.9	Cooling sea water pressure or flow	● ↓	■	-
1.10	Exhaust gas temperature in main line	↑	-	-
1.11	Exhaust gas temperature at each cylinder outlet[6]	◗ ↑ ▼[2]	-	-
1.12	Exhaust gas temperature. Deviation from mean value by cylinders[6]	↑	-	-
1.13	Starting air pressure before starting valve	● ↓	-	-
1.14	Air pressure in engine control systemv	↓	-	-
1.15	Scavenging air temperature at scavenging air cooler outlet	↑	-	-
1.16	Fuel oil pressure at high-pressure pump inlets	◗ ↓	■	

1.17	Fuel oil viscosity (temperature) at engine inlet[7]	↑(↓)		
1.18	Fuel oil level in daily service tank	↓	-	-
1.19	Fuel oil leakage from high-pressure piping	○	-	-
1.20	Engine speed	● ↑	-	**X**
1.21	Power supply for control, alarm and protection system	○	-	-
1.22	Gas concentration in machinery spaces[8]	↑	-	-
1.23	Rated speed of turbocharger [10]	● ↑	-	-
2	**Boilers of machinery installation[9]**			
3	**Internal combustion engines used as generator drives**			
3.1	Lubricating oil pressure at engine inlet	↓	-	**X**
3.2	Coolant pressure or flow at engine inlet	↓	-	-
3.3	Coolant temperature at engine outlet	↑	-	-
3.4	Fuel oil leakage from high-pressure piping	○	-	-
3.5	Engine speed	● ↑	-	**X**
3.6	Starting air pressure (before starting valve)	↓	-	-
4	**Reduction gear**			
4.1	Lubricating oil pressure at reduction gear inlet	↓	-	**X**
4.2	Lubricating oil temperature in reduction gear	↑	-	-
5	**Starting air compressors**			
5.1	Lubricating oil pressure at compressor inlet	↓ □	-	-
5.2	Air temperature at compressor outlet	↑	-	-
6.	**Tanks**			
6.1	Lubricating oil level in daily service tanks tank service	↓	-	-
6.2	Oil leakage level in oil leakage tank	↑	-	-
6.3	Fuel oil level in daily	↓	-	-
6.4	Fuel oil level in overflow tank	↑	-	-
6.5	Coolant level in expansion tank	↓	-	-
7	**Ship mains**			
7.1	Voltage	● ↑ ↓	-	-
7.2	Load (current)	● ↑	-	-
7.3	Current frequency	● ↓	-	-
7.4	Insulation resistance	↓	-	-

Symbols:

● — remote indication (continuous);
◗ — remote indication (on call);
↑ — alarm for high value;
↓ — alarm for low value;
○ — alarm signal,
■ — automatic start of stand-by pumps;
□ — compressor shutdown;
▼ — slowdown;
X — engine shutdown

[1] When independent stand-by pumps are available.
[2] Special visual and audible alarm may be provided instead of slowdown.
[3] When an independent lubrication pump is available.
[4] For low-speed engines with cylinder bore over 300 mm and dual-fuel low-speed engines in accordance with the requirements of **9.5.2.3**, Part IX "Machinery".
[5] For medium- and high-speed engines with cylinder bore over 300 mm and dual-fuel medium- and high-speed engines in accordance with the requirements of **9.3.2.3**, Part IX "Machinery".
[6] For engines with cylinder output above 500 kW.
[7] When working on heavy fuel.
[8] Required, where installations with dual-fuel (gas - liquid fuel) engines are used.
[9] Refer to Table 4.3.11.
[10] Only for turbochargers of Categories B and C (refer to **2.5.7.5**, Part IX "Machinery").
Note. For Group 1 parameters a common sensor is provided for indication, alarm and safety systems (for slowdown);
for Group 2 parameters - a sensor for automatic start of stand-by pumps;
for Group 3 parameters - a sensor of safety system (engine shutdown).

6.2 EQUIPMENT ARRANGEMENT ON THE BRIDGE

6.2.1 Provision shall be made for a remote control station for main machinery and/or propellers in conformity with **3.2**, Part VII "Machinery Installations".

6.2.2 As far as applicable, provision shall be made for remote control of essential auxiliaries.

6.2.3 Provision shall be made for shutting down the oil burning installations of automated boiler plants, incinerators, machinery space fans, fuel oil pumps, if any.

6.2.4 An alarm device shall be fitted to indicate malfunction of the machinery installation in accordance with **4.9.2**.

6.2.5 On the bridge, provision shall be made for the following separate alarms:

"Water in machinery space";

"Fire in machinery space";

"Alarm system failure";

as well as separate alarm "High gas concentration in machinery space", if the ship is provided with main and/or auxiliary dual-fuel (gas - liquid fuel) engines.

6.2.6 Visual alarm shall be provided to indicate acknowledgement of alarms in machinery space as required in **6.2.4** and **6.2.5**.

6.2.7 Provision shall be made for remote drainage of bilge wells in machinery spaces. The requirements of **4.7.2 - 4.7.4** shall be complied with**.**

6.3 EQUIPMENT ARRANGEMENT IN MACHINERY SPACES

6.3.1 In the vicinity of the main machinery local control station alarms and indicators of parameters, as stipulated by Table **6.1.3**, shall be provided.

6.3.2 As far as applicable, the controls of auxiliaries shall be located in conformity with **4.10.2**.

6.3.3 Where provision is made for an enclosed main machinery control room, the applicable requirements of **4.10.3 - 4.10.6** shall be complied with.

6.4 DEVICES IN ENGINEERS' ACCOMMODATION

6.4.1 As far as applicable, the requirements of **4.11** shall be complied with.

7. COMPUTERS AND COMPUTER-BASED SYSTEMS

7.1 APPLICATION

7.1.1 The requirements of this Section apply to computers and computer-based systems used for monitoring and control of essential machinery and arrangements, which ensure in combination with other automation systems (requirements thereto are set forth in Sections **2** to **6**) the operation of the machinery installation with unattended machinery spaces.

Ships fitted with such automation systems may be assigned, in accordance with **2.2.6**, Part I "Classification", one of the following distinguishing automation marks in the class notation:

.1 AUT1-C, AUT2-C or AUT3-C — where automation of the machinery installation is based on computers or programmable logic controllers;

.2 AUT1-ICS, AUT2-ICS or AUT3-ICS — where computer-based systems are combined into a network forming a common integrated system.

7.1.2 The requirements of this Section apply also to computers and computer-based systems used for control of non-essential machinery and devices where loss of control results in serious damage to the ship or its machinery, e.g. explosion of domestic water boilers.

7.2 DEFINITIONS AND EXPLANATIONS

7.2.1 In this section, in addition to the definitions and explanations given in 1.2, the following definitions are adopted:

Owner is a Party developing a relevant specification and responsible for contracting for supply of computer-based system, sub-systems and software with the system integrator and (or) suppliers providing these products in accordance with the specification. The owner is usually the builder or shipyard during construction. After ship delivery, the owner may delegate some responsibilities to the shipowner or operator.

Node is a point of interconnection to a data communication link.

Simulation tests are computer-based system testing where the object under control as well as data communication links are partly or fully replaced with simulation tools, or where parts of the communication network and lines are replaced with simulation tools.

Integrated system is a combination of computer-based systems, which are interconnected, in order to allow centralized access to sensors information and/or command/control.

Interface is a transfer point, at which information is exchanged. Examples of interface include: input/output interface used for interconnection with sensors and actuators; man-machine interface, e.g. monitors, keyboards, tracker-balls, etc. used for communication between the operator and the computer; communications interface used to enable serial communications/networking with other computers or peripherals.

Computer is a programmable electronic device for storing and processing data in the digital form, making calculations or performing control. A computer may be monoblock or may consist of several interconnected units.

Computer -based system is a system of one or more computers, associated software, peripherals and interfaces.

International Telecommunication Union (ITU) is an international organization that defines recommendations in the field of telecommunications and radio, as well as regulating the international use of radio frequencies.

Monitor is an electronic device for representing data.

Peripheral is a device performing an auxiliary action in the system, e.g. printer, data storage device, etc.

Quality Plan is a document containing information on the requirements prescribed by the quality management system to be applied for the specific computer-based system and/or software, the minimum scope of which is specified in **7.5.2.2**.

Supplier is a contracted or subcontracted provider (party) of computer-based system, sub-systems and/or software to the system integrator and/or owner, under the coordination of the system integrator or shipyard. The supplier also provides a description of the software functionality that meets the owner's specification, applicable international and national standards, and the requirements specified in the Register rules.

Software is programs, data and documentation associated with the operation of a computer-based system.

Programmable logic controller (PLC) is a computer device designed as a stand-alone functional unit and intended to perform functions relevant to control and monitoring of ship's machinery and processes.

System Integrator is a party integrating computer systems, sub-systems and software provided by suppliers into the system, into the system invoked by the requirements specified herein, as well as creating an integrated system. The system integrator may also be responsible for installation and integration of systems in the ship.

The role of system integrator are taken by the builder/shipyard. An alternative organization may specifically contracted/assigned the system integrator's responsibilities, provided the corresponding contract is available. If there are multiple parties performing system integration at any one time a single party may be a system integrator to coordinate the integration activities.

If there are multiple stages of integration different System Integrators may be responsible for specific stages of integration but a single party shall be responsible for defining and coordinating all of the stages of integration.

7.3 GENERAL REQUIREMENTS FOR THE DESIGN OF COMPUTER SYSTEMS USED FOR CONTROL AND MONITORING

7.3.1 Computer-based systems shall fulfil the functional requirements of the system under control for all operating conditions including emergency conditions, taking into account:

danger to persons;

environmental impact; damage to equipment;

usability;

operability of non-computer devices and systems.

7.3.2 If process times for functions of the system are shorter than the reaction times of the operator and therefore damage cannot be prevented by manual intervention, means of automatic intervention shall be provided.

7.3.3 A computer-based system shall have sufficient capability to: perform necessary autonomous operations; accept operator (user) commands; inform the operator (user) correctly under all operating conditions including emergency.

7.3.4 System capability shall provide adequate response times for all functions, taking into consideration the maximum load and maximum number of simultaneous tasks, including network communication speed, under normal and abnormal process conditions.

7.3.5 Computer-based systems shall be designed in such a way that they can be used without special previous knowledge, otherwise appropriate assistance shall be provided for the user.

7.3.6 Computer-based systems shall be protected against unintentional or unauthorized modification of programs and data.

7.4 HARDWARE REQUIREMENTS

7.4.1 Hardware shall function reliably in conditions normally encountered in ships as specified in **2.1**.

7.4.2 The design of the hardware shall ensure easy access to interchangeable parts for repairs and maintenance.

7.4.3 Each replaceable part shall be simple to replace and shall be constructed for easy and safe handling. All replaceable parts shall be arranged in such a way that it is not possible to connect them incorrectly or to use incorrect replacements.

Where this is not practicable, the replaceable parts shall be clearly marked.

7.5 SOFTWARE REQUIREMENTS

7.5.1 General.

7.5.1.1 The software development procedure shall comply with the applicable international or national standards spanning the software lifecycle and integration of the latter into an appropriate computer-based system.

7.5.2 Вимоги до системи менеджменту як Quality Management Systems Requirements ості.

7.5.2.1 System integrators and suppliers shall operate a quality system regarding software development and testing and associated hardware such as ДСТУ ISO 9001 or the relevant ISO standard, taking into account, ДСТУ ISO/IEC 90003 or relevant ISO or IEC standards, etc.

7.5.2.2 The quality management system specified in **7.5.2.1** shall include the following:

.1 relevant procedures regarding responsibilities, system documentation, software configuration management and competent staff;

.2 procedures regarding organization set in place for acquisition of related software and hardware from suppliers;

.3 procedures regarding organization set in place for software code writing and verification. Having a specific procedure for programmable electronic systems verification of Category II and III (refer to **7.10.3**) at the level of systems, sub-systems and programmable devices and modules.

Having check points for Category II and III systems and providing possible verification by the Register, i.e submitting technical documentation to the Register for review, performing the relevant tests, submitting the peer review results to the Register and audits of the firm's technical control, etc., in compliance with **7.10.8**;

.4 having a specific procedure for software installation and amendments thereto on board the ship including interactions with owners.

7.5.3 Software lifecycle.

7.5.3.1 Design.

.1 risk assessment of system.

This step shall be undertaken to determine the risk to the system throughout the lifecycle by identifying and evaluating the hazards associated with each function of the system.

A risk assessment report shall be submitted to the Register upon request. This document shall normally be submitted by the system integrator or the supplier, including data received from other suppliers.

IEC/ISO 31010 "Risk management - Risk assessment techniques" may be applied to determine a method of risk assessment. The method of risk assessment shall be defined in the report submitted to the Register.

If based on the risk assessment, system category is changed; such changes shall be submitted to the Register for review.

Where the risks associated with a computer-based system are well understood, the risk assessment may be omitted upon submission of the relevant justification by the supplier or system integrator. Such justification shall include the following:

risk identification technique;

equivalence of the context of use of the current computer-based system and the computer-based system initially used to determine the risks;

adequacy of existing control measures in the system intended use under consideration.

.2 code production and testing.

The following documentation shall be provided to the Register for Category II and III systems (refer to **7.10.3**) by the supplier and system integrator:

software modules functional description and associated hardware description for programmable devices;

evidence of verification (detection and correction of software errors) for software modules, in accordance with the selected software development standard. Evidence requirements of the selected software standard may differ depending on how critical the correct operation of the software is to the (function it performs (for example, IEC 61508 or the relevant IEC or EN standards have different requirements depending on Safety Integrity Levels (SILs), similar approaches are taken by other recognized standards);

In addition, for Category II and III systems evidence of functional tests for programmable devices at the software module, subsystem, and system level shall be supplied by the supplier via the system integrator. The functional testing shall be designed to test provided by the operating system, function libraries, software shell, etc. and used by the inspected software.

7.5.3.2 Integration testing before installation on board.

Intra-system integration testing shall be carried out between system and sub-system software modules before being integrated on board. The objective is to check that software functions are properly executed, that the software and hardware it controls interact and function properly together and that software systems react properly in case of failures. Faults shall be simulated as realistically as possible to demonstrate appropriate system fault detection and system response. The results of integration testing shall also confirm findings of the appropriate failure mode and effects analysis (FMEA), if the latter shall be submitted according to the requirements of the Rules. Functional and failure testing can be demonstrated by simulation tests.

7.5.3.3 Approval of programmable devices. Programmable devices integrated inside a computer-based system shall be delivered with the RS documents listed in the Nomenclature of items of the Register technical supervision (refer to Appendix 1, Part I "General Regulations for Technical Supervision" of the

Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships).

List of technical documentation submitted to the Register in addition to the documentation specified in **1.4.1**, as well as the list of relevant tests and checks is specified in **7.10.8**. Technical documentation shall address the compatibility of the programmable device with the relevant computer-based systems in the ship's application, list of necessary tests to be carried out on the ship during integration into the ship computer-based systems and it shall identify the programmable device scope of application as well as the ship computer-based system components using, if possible, such a device.

7.5.3.4 Final integration and on board testing.

.1 prior to final integration the simulation tests of a computer-based system shall be undertaken to check safe interaction of the latter with other computerized systems and functions that could not be tested previously;

.2 after final integration of the computer-based system the relevant tests shall be carried out on board to check the computer-based system in actual operating conditions and integrated with all other systems in interaction:

performing functions it was designed for;

reacting safely in case of failures originated internally or by devices external to the system;

interacting safely with other systems implemented on board a ship.

The list of relevant tests and checks is given in **7.10.8**.

7.5.3.5 Software modifications during operation.

7.5.3.5.1 Responsibilities.

.1 organizations in charge of software modifications during operation shall be clearly declared by owner to the Classification Society. A system integrator shall be designated by the owner and shall fulfil the requirements specified in **7.5.1**, **7.5.2**, **7.5.3.1 – 7.5.3.4**.

.2 during the ship operation, it is the responsibility of the owner to manage traceability of these modifications.

The system integrator shall support traceability of these modifications by updating the software registry. This software registry shall contain the following:

list and versions of the software installed in Category II and III systems;

date and results of the software security scans carried out in accordance with **7.5.3.6**.

7.5.3.6 Software security.

Owner, system integrator and suppliers shall adopt security policy and include it in their quality management systems.

For Category I, II, and III systems, physical and logical security measures shall be in place to prevent unauthorized or unintentional modification of control software or limiting values of controlled parameters within the computer-based systems, the appropriate structural means and organizational measures shall be provided. The above means and measures shall provide protection whether undertaken directly at the physical system or remotely.

Prior to software installation on board, the software code, executables and physical medium used for installation on the ship shall be scanned for viruses and malicious software. Results of the scan shall be documented and kept with the software registry.

7.6 SYSTEM CONFIGURATION REQUIREMENTS

7.6.1 General.

7.6.1.2 The hardware and software shall be of modular, hierarchical design in order to maximize the fault tolerance of the system.

7.6.1.2 The selection of the computer equipment shall be consistent with safe operation of the system under control.

7.6.2 Self-test. Computer-based systems shall have self-test capability to monitor for correct operation and alarm shall be given for an abnormal condition.

7.6.3 Power supply.

7.6.3.1 The sources of power supply shall be monitored for failure and shall give an alarm in the event of abnormal condition.

7.6.3.2 Program and data held in the system shall be protected from corruption by loss of power.

7.6.3.3 Redundant systems shall be selectively fed and separately protected against short circuits and overloads.

7.6.4 Installation.

7.6.4.1 Equipment and its associated cabling shall be installed in such a way as to minimize electromagnetic interference between the equipment concerned and other equipment on board.

7.6.4.2 Cables used for data communication shall be of adequate mechanical strength, suitably supported and also protected from mechanical damage.

7.6.5 Data communication links.

7.6.5.1 The data communication link shall be continuously self-checking, for detecting failures on the link itself and data communication failure on nodes and shall give an alarm in the event of abnormal condition.

7.6.5.2 When the same data communication link is used for two or more essential functions, this link shall be redundant. Redundant data communication links shall be routed with as much separation as practical.

7.6.5.3 Switching between redundant links shall not disturb data communication or continuous operation of functions. An automatic switching alarm signal shall be transmitted.

7.6.5.4 To ensure that data can be exchanged between various systems, standardized interfaces shall be used.

7.6.6 Fail-to-safe principle.

7.6.6.1 In the event of a failure of a computer-based system, systems under control shall automatically revert to the least hazardous condition.

7.6.6.2 The failure and restarting of computer-based systems shall not cause processes to enter undefined or critical states.

7.6.6.3 Control, alarm and safety functions shall be arranged such that a single failure will not affect more than one of these functions.

7.6.7 Integration of systems.

7.6.7.1 Operation with an integrated system shall be at least as effective as it would be with individual, stand-alone equipment. Where multifunction displays and controls are used they shall be duplicated and interchangeable.

7.6.7.2 Failure of one part (individual module, equipment or subsystem) of the integrated system shall not affect the functionality of other parts, except for those functions directly dependent upon information from the defective part.

7.6.7.3 A complete failure in connectivity between parts shall not affect their independent functionality.

7.6.7.4 An alternative means of operation, independent of the integration, shall be available for all essential functions.

7.6.7.5 When systems under control are required to be duplicated and in separate compartments this shall be also applied to computer-based systems used for control and monitoring.

7.7 USER INTERFACE

7.7.1 General.

7.7.1.1 Computer-based systems shall be designed for ease of handling and user-friendliness and shall follow ergonomic principles.

7.7.1.2 The operational status of a computer-based system (on, off, non-failed, failed, etc) shall be easily recognizable.

7.7.1.3 A user manual shall be provided. The user guide shall describe for example: function keys; menu displays; computer-guided dialogue steps, etc.

7.7.1.4 An alarm shall be displayed at relevant operator stations for failure or shutdown of a subsystem.

7.7.2 Input devices.

7.7.2.1 Input devices shall have clearly definable functions, be reliable in use and operate safely under all conditions. The acknowledgement of the instruction given shall be recognizable.

7.7.2.2 Dedicated function keys shall be provided for frequently recurring commands and for commands, which shall be available for rapid execution. If multiple functions are assigned to keys, it shall be possible to recognize, which of the assigned functions is active.

7.7.2.3 Control panels on the bridge shall be provided with separate lighting. The level of lighting and the brightness of visual display units shall be controllable.

7.7.2.4 Where equipment operations or functions may be changed via keyboards access to such operations shall be provided for authorized personnel only.

7.7.2.5 If operation of a key is able to cause dangerous operating conditions, measures shall be taken to prevent the instruction in question from being executed by a single action such as:

use of a special key lock;

use of two or more keys.

7.7.2.6 Conflicting control interventions shall be prevented by means of interlocks or warnings. The active control status shall be recognizable.

7.7.2.7 The operation of input devices shall be logical and correspond to the direction of action of the controlled equipment.

7.7.3 Output devices.

7.7.3.1 The size, colour and density of text and graphic information displayed on a visual display unit shall be such that it may be easily read from the normal operator position under all operational lighting conditions.

The brightness and contrast shall be capable of being adjusted to the prevailing ambient conditions in order to enable the information to be normally recognized.

7.7.3.2 Information shall be displayed in a logical priority.

7.7.3.3 If alarm messages are displayed on colour monitors, the distinctions in the alarm status shall be ensured even in the event of failure of a primary colour.

7.7.4 Graphical user interface.

7.7.4.1 Information shall be presented clearly and intelligibly according to its functional significance and association.

Screen contents shall be logically structured and their representation shall be restricted to the data, which is directly relevant for the operator.

7.7.4.2 When using general purpose graphical user interfaces, only the functions necessary for the respective process shall be available.

7.7.4.3 Alarms shall be visually and audibly presented with priority over other information in every operating mode of the system; they shall be clearly distinguishable from other information.

7.7.4.4 All display and control functions in control stations operated by the same operators shall adopt a consistent user interface.

Particular attention shall be paid to symbols, colours, controls, information priorities and layout.

7.8 TRAINING

7.8.1 Training shall be provided at a level required to effectively operate and maintain the system and shall cover normal, abnormal and emergency conditions.

The user interface for training shall correspond with the real system.

7.8.2 Documentation shall be provided to support the training and shall be available for repeated use on board during maintenance of the computer systems.

7.8.3 Where a training mode is incorporated in a computer-based system it shall be clearly indicated when the training mode is active.

7.8.4 Whilst in the training mode the operation of the system shall not be impaired, and neither are any system alarms or indications to be inhibited.

7.9 TESTS AND CHECKS

7.9.1 The computer-based systems shall be designed, manufactured and tested in accordance with the requirements of this Section and other requirements of the Rules.

In the case of any integrated systems, evidence shall be furnished by a party responsible for the integration that the requirements applied to the integration of the subsystems have been fully satisfied.

7.9.2 In addition to the requirements of the Section, manufacturers shall ensure by means of quality control system that their products meet with their specifications.

7.9.3 Tests and checks of a computer-based system shall be carried out with the aim of establishing the correct operation and the quality of a product.

7.9.4 Modifications of program contents and data, as well as change of version, shall be checked and tested.

7.10 PROGRAMMABLE ELECTRONIC SYSTEMS

7.10.1 Scope.

These requirements apply to the use of programmable electronic systems which provide control, alarm, monitoring or safety functions in addition to the requirements set forth in this Section. Navigational equipment and ship loading instruments are excluded.

7.10.2 General.

7.10.2.1 Programmable electronic systems are to fulfill the requirements of the system under control for all operating conditions, taking into account danger to persons, environmental impact, damage to ship as well as equipment, usability of programmable electronic systems and operability of non computer devices and systems, etc.

7.10.2.2 When systems or their devices and components other than provided by these Rules are applied, an engineering analysis carried out in accordance with a relevant international or national standard and proving the equivalent effectiveness of the specified systems, devices and components with regard to those determined in these Rules in accordance with **1.3.4** of General Regulations for the Classification and Other Activity, shall be obligatory submitted to the Register.

7.10.2.3 The use of unconventional technology for category III systems shall not be permitted.

7.10.3 System categories.

7.10.3.1 Programmable electronic systems shall be assigned into three system categories as shown in Table 7.10.3.1 according to the potential (possible) extent of the damage caused by a single failure within the programmable control and monitoring electronic systems.

Table 7.10.3.1 **System categories.**

Category	Effects	System functionality
I	Those systems, failure of which will not lead to dangerous situations for human safety, safety of the ship and/or threat to the environment	Monitoring function for informational/administrative tasks
II	Those systems, failure of which could eventually lead to dangerous situations for human safety, safety of the ship and/or threat to the environment	Alarm and monitoring functions; control functions which are necessary to maintain the ship in its normal operational and habitable conditions
III	Those systems, failure of which could immediately lead to dangerous situations for human safety, safety of the ship and/or threat to the environment	Control functions for maintaining the ship's propulsion and steering; safety functions

Note: 1. Consideration shall be given to the extent of the damage directly caused by a failure, but not to any consequential damage.

2. Identical redundancy will not be taken into account for the assignment of a system category.

7.10.3.2 Assignment of a programmable electronic system to the appropriate category shall be carried out depending on the greatest likely extent of direct damage to machinery and equipment, based on risk assessment for all operating conditions of the ship specified in **3.1.5** of Part XI "Electrical Equipment".

The relevant examples of the assignment of a programmable electronic system to the appropriate categories are given in Table 7.10.3.2. The list of the examples given is not exhaustive.

Table 7.10.3.2 **Examples of assignment to system categories.**

System category	Examples
I	Maintenance support system Information system Diagnostic system
II	Liquid cargo transfer control system Automation system for bilge pumping system of machinery spaces Fuel oil treatment automation system Ballast remote automatic control system Stabilization and ride control systems Alarm and monitoring systems for propulsion systems
Ш	Control system of propulsion system of a ship, meaning the means to generate and control mechanical thrust in order to move the ship. Control system of devices used only during manoeuvring (e.g. bow tunnel thrusters) are not in the scope of this requirement Steering system control system Electric power system (including power management system)

III	Fire detection system Fire-fighting system Flooding detection and fighting system Control bilge system Internal communication systems involved in evacuation phases Ship systems involved in operation of life saving appliances equipment Control system of dynamic positioning system of equipment classes 2 and 3

7.10.4 Data communication links.

7.10.4.1 These requirements apply to system categories II and III using shared data communication links (local network) to transfer data between programmable electronic systems and equipment.

7.10.4.2 Loss of a data communication link shall be specifically addressed in risk assessment analysis.

If a single failure in any component of the data communication link hardware or software causes loss of data communication link, they shall be automatically treated in order to restore proper working of the data communication means shall be provided to automatically restore data communication.

For category III systems a single failure in data communication link hardware shall not influence the proper working of the system in general.

7.10.4.3 Loss of a data communication link shall not affect the ability to operate essential services by alternative means.

7.10.4.4 Means shall be provided to ensure the integrity of data and provide timely recovery of corrupted or invalid data.

7.10.4.5 The data communication link shall be self-checking, detecting failures on the link itself and data communication failures on nodes connected to the link. Detected failures shall initiate an alarm.

7.10.4.6 System self-checking capabilities shall be arranged to initiate transition to the least hazardous state for the complete installation in the event of data communication failure.

7.10.4.7 The characteristics of the data communication link shall be such as to transmit all necessary information in adequate time and to prevent overloading.

7.10.4.8 At least the following local network hardware statuses shall be monitored:

link up of each port on the network device/network topology change;

link down of each port on the network device;

power on or network hardware reset;

temperature increase of network devices in case this parameter is critical for operation, and the manufacturer has provided its necessary monitoring.

7.10.5 Additional requirements for wireless data communication links.

7.10.5.1 For system category III, the use of wireless data communication links is not allowed.

7.10.5.2 Functions that are required to operate continuously to provide essential services dependant on wireless data communication links shall have an alternative means of control that can be brought in action within an acceptable period of time.

7.10.5.3 Wireless data communication shall employ recognized international wireless communication system protocols that incorporate the following:

.1 message integrity. Fault prevention, detection, diagnosis, and correction so that the received message is not corrupted or altered when compared to the transmitted message;

.2 configuration and device authentication. Shall only permit connection of devices that are included in the system design;

.3 message encryption. Protection of the confidentiality and or criticality the data content;

.4 security management. Protection of network assets, prevention of unauthorised access to network assets.

7.10.5.4 The wireless system shall comply with the radio frequency and power level requirements of International Telecommunications Union and flag state requirements. Consideration shall be given to system operation in the event of port state and local regulations that pertain to the use of radio-frequency transmission prohibiting the operation of a wireless data communication link due to frequency and power level restrictions.

7.10.5.5 During mooring and sea trials for wireless data communication equipment, tests shall be conducted to demonstrate that radio-frequency transmission does not cause failure of any equipment and does not its self-fail as a result of electromagnetic interference via wireless data communication links during expected operating conditions.

7.10.6 Protection against modifications.

7.10.6.1 Programmable electronic systems of category I and II shall be protected against program modification by the unauthorized personnel (user).

7.10.6.2 For systems of category III modifications of parameters by the manufacturer shall be approved by the Register.

7.10.6.3 Any modifications in software or hardware made after performance of the tests witnessed by the Register as per item **6** of Table 7.10.8 shall be documented and submitted to the Register for approval.

7.10.7 Technical documentation.

7.10.7.1 For approval of programmable electronic systems of category II and III documentation in compliance with 1.4 shall be submitted.

When alternative design or arrangement is intended to be used, an engineering analysis carried out in accordance with a relevant international or national standard shall be submitted in addition (refer to **7.10.2.2**).

7.10.7.2 For all tests required in accordance with the system category a test program shall be submitted and the test results shall be documented (by reports).

7.10.7.3 Additional documentation may be required for systems of category III.

The documentation shall include a description of testing methods and required test results.

7.10.7.4 For wireless data communication equipment, the following additional technical documentation shall be submitted

.1 details of manufacturer's recommended installation and maintenance practices;

.2 network plan with arrangement and type of antennas and identification of location;

.3 specification of wireless communication system protocols and management functions (refer to **7.10.5.3**);

.4 details of radio frequency and power levels;

.5 evidence of type testing in accordance with shipboard conditions;

.6 on-board test program (mooring and sea trials).

7.10.7.5 Necessary documents for approval of programmable electronic systems of category I shall be submitted if requested.

7.10.7.6 All changes or modifications shall be documented by the manufacturer and submitted to the Register for review and approval.

Subsequent significant modifications to the software and hardware for system categories II and III shall be submitted anew for review and approval.

Note . A significant modification is a modification which influences the functionality and/or safety of the system.

7.10.8 Tests and evidence.

Tests and appropriate documents (reports, certificates) shall be issued in accordance with Table 7.10.8.

***Table 7.10.8* Tests and evidence according to system category**

Requirement	**Supplier**	**System integrator**	**Owner**	**Category I[1]**	**Category II**	**Category III**
1	**2**	**3**	**4**	**5**	**6**	**7**
Quality Plan	**x**	**x**		**A[2]**	**A**	**A**
Risk assessment report		**x**		**I[2]**	**I[2]**	**I[2]**
Software modules functional description and associated hardware description	**x***(if necessary)*	**x**			**I**	**I**
Evidence of verification of software code	**x***(if necessary)*	**x**			**I**	**I**
Evidence of functional tests for elements included in systems of Category II and III at the level of software module, sub-system and system.	**x**	**x**			**I**	**I**
Factory acceptance test including functional and failure tests	**x**	**x**			**W**	**W**
Test programs and procedures for functional tests and failure tests including a supporting FMEA or equivalent, at the Register request, depending on available relevant requirements in the rules.		**x**			**A**	**A**

Test program for simulation tests for final integration of the system		**x**			**A**	**A**
Simulation tests for final integration of the system		**x**			**W**	**W**
Test program for on-board tests - mooring and sea (includes wireless data communication testing)		**x**			**A**	**A**
On-board mooring and sea tests (includes wireless data communication testing)		**x**				
List and versions of software installed in system		**x**				
Functional description of software						
User manual including instructions during software maintenance						
List of interfaces between system and other ship systems						
List of standards for data communication links						
Additional documentation, at the Register request, if relevant requirements are available in the rules including "Failure modes and effects analysis" (FMEA) or an equivalent document						
Updated software registry		**x**	**x**		**I**	**I**
Procedures and documentation related to security policy		**x**	**x**		**I**	**I**
Test program for compliance with the shipboard service conditions	**x**	**x**		**A**[3]	**A**	**A**
Tests for compliance with the shipboard service conditions	**x**	**x**			**W**	**W**
Test reports according to the shipboard service conditions	**x**	**x**		**A**[3]	**A**	**A**

Symbols:

x - – the Party shall design and submit the relevant technical documentation to the Register for review and/or carry out the relevant tests and submit the item of technical supervision to the Register;

A – technical documentation shall be submitted for approval;

I – technical documentation shall be submitted for reference (for information purposes);

W – the Register representative shall take part in the tests.

[1] The Register may request additional technical documentation if relevant requirements are available in the Rules.

[2] Risk assessment is permissible to be omitted considering the requirements of **7.5.3.1.1**.

[3] If relevant requirements are available in the Register rules.

8. DYNAMIC POSITIONING SYSTEMS

8.1 APPLICATION AND MARKS IN CLASS NOTATION

8.1.1 The requirements of this Section apply to the following: electric and electronic equipment of the dynamic positioning systems; automated control systems for thruster units.

8.1.2 Observance of the requirements of this Section and applicable requirements of other sections of this Part is mandatory for ships, which are assigned in compliance with **2.2.9**, Part I "Classification", one of the following marks: **DP1**, **DP2** or **DP3**, added to the class notation

8.2 DEFINITIONS AND EXPLANATIONS

8.2.1 In this section, in addition to the definitions and explanations given in **1.2**, the following definitions are adopted

Power supply system means the system necessary to supply the dynamic positioning system with power under all operating conditions including emergency ones and comprising:

prime movers of generators with necessary piping and auxiliary systems including fuel, cooling, lubrication oil, hydraulic, pneumatic and pre-heating systems;

generators;

switchboards;

cabling.

The power sypply system can be both a specialized and a single power system of the vessel.

Single failure in dynamic positioning system means a failure in active components (thruster, its local control system, power generator, automated valve), or one passive element (piping, power or control cable, manually operated valve, etc.).

Redundancy of dynamic positioning system means duplication or multiple redundancy of its components, at which an installation consisting of an power supply system and thruster units with their individual control systems is functioning under control of a computer-based system in such a way that failure of particular control systems, particular thruster units or components of the power supply system does not affect the performance of the task to ensure the ship position keeping and/or heading holding.

Dynamic positioning system (DP system) means the complete installation intended for control of power supply system of the ship, auxiliary thrusters, propulsion plants, steering gear, if part of the dynamic positioning system, in order to dynamically keep position and/or heading of the ship with prescribed accuracy under the action of disturbing environmental forces. The dynamic positioning system shall comprise, but not be limited to, the following main systems:

electric power supply system;

thruster (propulsor) units to supply the DP-system with necessary thrust force and direction in order to compensate for environmental factors;

control system consisting of computerbased system with appropriate software, data displays, a system of external force and ship's position sensors, as well as setpoint devices.

Thruster system means the system intended for providing adequate thrust in longitudinal and lateral directions at each instant of time as well as yawing moment which can compensate for the environmental factors affecting the ship.

The system shall comprise the following items:

thrusters with drives and auxiliary equipment including hydraulic piping and tanks (if any);

main propulsion plant of the ship with supporting systems and steering gear if under the dynamic positioning system control;

means for individual manual control of each propulsion unit, steering gear and thruster; and

associated cabling connecting all system's machinery and systems to the dynamic positioning control system.

Dynamic positioning control system (DP control system) means a computer-based programmable system intended for automatic and remote automated control of the auxiliary thrusters, propulsion plants, steering gear, if part of the dynamic positioning system, in order to dynamically keep position and/or heading of the ship with prescribed accuracy under the action of disturbing environmental forces, and consisting of the following:

computer-based system with associated software and interfaces for generation of control signals in automatic mode or with the use of a single control device (joystick);

operator panel system with controls and data displays;
position reference systems;
external force sensors;
power cabling;
information and control cabling.

8.3 SCOPE OF SURVEYS

8.3.1 The following equipment of the DP system is subject to survey during manufacture and on board:
electric machines and electric machine converters of ship's power supply system;
electric drives of propulsion units, steering gear and thrusters;
power static semi-conductor converters and transformers;
switchboards;
switchgear and control gear and protective devices;
uninterruptable power supply arrangements;
power and control, including information, cabling;
control and monitoring consoles of dynamic positioning control system;
computers and computer-based systems with software; ship's position reference systems,
other types of equipment - at the request of the Register.

8.4 TECHNICAL DOCUMENTATION

8.4.1 Prior to commencement of survey of the DP-system electric and electronic equipment during manufacture thereof, the following documentation shall be submitted to the Register for consideration:

the specification with description of the operating principle and justification of the system redundancy level;

list of equipment used with indication of the devices and units used and their performance data;

layout of the thruster units and cable routing diagram with indication of methods used for cable installation and penetration through watertight and fire-proof bulkheads;

general arrangement plans of the control consoles and panels with indication of primary and secondary control stations;

schematic and functional diagrams for electric power plant control;

functional diagrams for computerized control system with indication of the inputs and outputs with feedback, self-check system and alarm and monitoring system;

layout and diagram of the ship's position sensors and their connections with control system;

test program for control system;

Failure modes and effects analysis (FMEA) for dynamic positioning systems on ships with **DP2** and **DP3** in the class notation;

list of spare parts.

8.5 DESIGN OF THE DP SYSTEM, CLASSES

8.5.1 The design of the dynamic positioning control systems shall conform to the general requirements set forth in Section **2**.

8.5.2 Where the propulsion plant and rudder system of a self-propelled ship form part of the DP system, the requirements of this Chapter shall be fully applied thereto, in addition to the requirements placed upon the propulsion machinery and rudder system.

8.5.3 The DP systems shall be subdivided into classes based on their design capability to maintain position and/or heading of the ship if the worst-case failure occurs, as specified below.

8.5.4 Class 1 DP system, which corresponds by its characteristics to mark **DP-1** in the class notation, is a system with minimum redundancy as indicated in **8.5.8**. In this case, the loss of position and/ or heading of the ship may occur in the event of a single failure, as is specified in **8.2.1**.

8.5.5 Class 2 DP-system, which corresponds by its characteristics to mark **DP2** in the class notation, shall have such redundancy that a loss of position shall not occur in the event of a single failure in any active component of the system. Passive components of the system shall not be considered to fail where an adequate protection from mechanical damages and owing to the component properties is demonstrated confirmed by a certificate of the Register.

8.5.6 Class 3 DP system, which corresponds by its characteristics to mark **DP-3** in the class notation, shall have such redundancy that a loss of position and/or heading shall not occur in the event of a single failure or an accident under specified/considered environmental conditions according to the design in the system components in the following cases:

failure in any component, as indicated in **8.2.1**, as well as any passive component in the DP system;

failure in all active and passive components located in any one watertight compartment, from flooding or fire;

failure in all active and passive components located in any one fire subdivision, from fire or flooding.

8.5.7 For Class 2 and 3 DP systems, the controls of operator panels of the dynamic positioning control system shall be designed so that no single inadvertent act of the operator of the dynamic positioning control system can lead to a loss of position and/or change in heading.

8.5.8 Class 1 DP-system shall be designed with redundancy of the following components:

control systems of the installation (one manual control system and one computerized control system);

position sensors system.

8.5.9 Class 2 DP system shall be designed with redundancy of the following components:

power supply system;

thrusters with their local control systems;

computer-based systems with the operator panels and controls of DP control system;

position reference systems.

8.5.10 Class 3 DP system shall be designed with redundancy of components as provided for Class 2, but in addition, all the redundant components shall be separated by "A-60" class fire-resisting bulkheads.

8.5.11 The redundant components ensuring single failure tolerance shall function continuously or be switched on automatically. Transfer to a redundant component shall be effected either automatically or by simple action of the operator. The transfer shall not cause excessive fluctuation of the positioning conditions.

8.6 POWER SUPPLY SYSTEM

8.6.1 The power system necessary to supply the thruster system shall have a sufficient capacity and shall respond in time to power demand changes caused by operating modes needed at the moment.

8.6.2 For Class 1 DP systems, the power system need not be redundant.

8.6.3 For Class 2 DP systems, the power system shall be divisible into two or more independent systems, so that after failure of one of them the remaining power supply systems can supply power to the connected thruster units with supporting systems to ensure maintaining of position and/or heading of the ship.

While in use, the power system may be run as a common electric power supply system.

8.6.4 For Class 3 DP systems, the power system shall have characteristics mentioned in **8.6.3**, but in addition, it shall be physically divided by "A-60" class division (bulkhead) into two or more independent systems.

Where the power supply systems are located onboard below the operational waterline, they shall be also divided by watertight bulkheads.

During operation, such systems shall function separately.

8.6.5 Where an automated power management system is provided, it shall be designed with redundancy.

8.6.6 The power management systems shall be supplied from both the main and the emergency source of electric power.

Where one of the power sources fails, alarm shall be released at the control stations.

8.6.7 The programmable electronic systems (computer-based or microprocessor (PLC) systems) shall be supplied in such a way as to minimize voltage bump, harmonic interference and to provide protection against erroneous connection (connection with a wrong polarity).

8.6.8 For the DP-systems designed with appropriate redundancy, depending on their class, the following arrangements shall be provided:

.1 the power system shall be equipped with an automatic changeover device to a back-up source having appropriate quality characteristics including those concerning stabilization;

.2 the change-over operations shall not interrupt or disturb procedures essential to the safety of the ship;

.3 particular attention shall be given to:

sufficiency of the accumulator battery capacity, consistency between the charging facilities and relevant accumulators;

invertor equipment;

load monitoring systems;

protection systems-earthing systems;

switchgear synchronizing devices to provide change-over to back-up energy sources or back-up power supply systems.

8.7 THRUSTER SYSTEM

8.7.1 Each electric drive of the thrusters shall be power supplied by a separate supply circuits without the use of common feeders or common protective devices and shall be provided with an independent device for emergency shutdown of electric motor actuated from the control station.

8.7.2 Each electric drive shall be provided with its own control system supplied by a separate circuit without the use of common feeders or common protective devices.

8.7.3 Propeller blade position and thrust azimuth (direction) of the rotatable thrusters in the event of electric drive failure shall remain unchanged without marked deviations.

Control of a thruster shall be restored manually.

8.7.4 To eliminate electromagnetic interaction between command signals, feedback signals of the local control systems of thruster units and electronic (computer-based) dynamic positioning control system, the mentioned control systems shall meet the requirements set forth in **2.2**, Part XI "Electrical Equipment".

8.7.5 Each power and hydraulic control system shall be provided with duplicated power supply via separate circuits without the use of common feeders or common protective devices.

8.7.6 Provision shall be made for back-up power supply circuits, which enable the power supply to be automatically changed over thereto, in the event of the main power failure, not only for the control system but also for the power circuit of the thrusters.

8.7.7 The operations to transfer the power supply of control systems from the main feeders to the backup ones shall not result in loss of power supply to equipment and devices.

8.7.8 The feedback signals of various parameters describing condition of the ship, the information on the power consumed to maintain position of the ship and some other parameters are the most important.

The DP-system shall be able to compare these signals, initiate the alarm system in the event of their faults and continue to maintain position of the ship using feedback signals from other sensors.

8.8 CONTROL STATIONS

8.8.1 The main dynamic positioning control station shall be generally located on the navigation bridge where the operator has a good view of the ship's exterior limits.

The panels of the DP-system control consoles shall be fitted with permanent visual alarm and indication of normal operational status of the following subsystems:

electric power supply system (number of running generators and converters, their load, availability of back-up sets),

power thruster system (number of thrusters, operating mode, load, status of local control systems),

dynamic positioning control systems (status of main and back-up power supply, values and directions of thrust produced by thrusters, with reference to the ship axes, indication of the ship's position on station, status of compute--based system and status of ship's position sensor system, other information needed to ensure safe functioning of the DPsystem).

Information regarding other parameters of particular devices and machinery shall be submitted to the operator on demand.

8.8.2 The display switching system and controls shall be designed with due regard to the national ergonomic standards.

The thruster control mode shall be selectable by simple actions of the operator and the mode selected shall be clearly distinguishable among the following control modes provided:

manual remote thruster control from local stations;

joystick thruster control from main control station;

automatic (computer) control.

8.8.3 For Class 2 and 3 DP-systems, the controls and electronic control logic shall be such that incompetent or unauthorized actions of the operator cannot cause disturbance of the normal positioning conditions.

8.8.4 The alarm and monitoring system of the DP-system shall meet the general requirements specified in **2.4**.

8.8.5 The alarm and monitoring system of the DP system, in addition to audible and visual signals relating to the DP system machinery and devices, shall contain textual and graphic information on failures of the system components and recommendations to the operator with respect of necessary arrangements to be made in order to keep the position of the ship.

8.8.6 The dynamic positioning control system shall be designed with a logic that would render fault development and transfer from one system to another impossible.

The redundant system components shall interact in such a manner that if one of these components fails, it is isolated (disconnected) while the other component is activated. The displays shall represent sufficient visual and audible information on transfer to the back-up component.

8.8.7 The control system shall provide for quick transfer from the automatic to remote automated control of the thrusters, propulsion plants and rudders, if involved in DP system operations, using both individual controls (according to the number of thruster units) and a single common joystick. Transfer from the remote automated to automatic control shall be effected with similar quickness.

8.9 COMPUTER-BASED DYNAMIC POSITIONING CONTROL SYSTEMS

8.9.1 The redundancy requirements shall not be applicable to computer-based systems in Class 1 dynamic positioning control systems.

8.9.2 Computer-based systems in Class 2 dynamic positioning control systems shall be duplicated and independent of one another. Malfunctions of common facilities, such as plant interfaces, arrangements for switching between systems, data transfer, data buses and software, including selfchecking routines shall not be capable of causing the failure of both systems.

8.9.3 Computer-based systems in Class 3 dynamic positioning control systems shall be duplicated as indicated in **8.9.2**, and furthermore, provision shall be made for an independent back-up dynamic positioning control system arranged in a special space separated by "A-60" class bulkhead from the main control station (refer also to **2.1.5.8**, Part VI «Fire Protection».

During normal dynamic positioning control, the back-up system shall be in "hot back-up" state in "on" condition and shall be automatically updated by data input from the position reference system and external force sensors, thruster system feedback sensors, etc.

Change-over of control to the back-up system shall be possible at all times and shall be effected manually from the back-up control station.

8.9.4 In computer-based systems of Class 2 and 3 DP systems the software function of continuous analysis shall be implemented to verify that heading will be maintained and/or the ship will remain in position if the worst-case failure occurs.

The analysis shall verify that, following the worst-case failure, the remaining in operation thrusters, propulsion plants and rudders, if involved in DP system operations, can generate the same resultant thrust and yawing moment as required prior to the accident under current environmental conditions.

8.9.5 The control systems with the software function of failure consequence analysis shall actuate warning alarm where the analysis outcome establishes DP system's inability to maintain position and/or heading of the ship.

8.9.6 For DP system operations, which will take a long time to safely terminate, the failure consequence analysis shall be capable of simulating the DP system behaviour after the worst-case failure based on manual inputs of weather trend.

8.9.7 Redundant computer-based systems shall be arranged with automatic transfer of control after a failure in one of the computer-based systems.

The automatic transfer of control from one computer-based system to another shall be smooth, without significant disturbing effects on the thruster system.

8.9.8 A dedicated uninterruptible power source (UPS) shall be provided for each DP control system to provide a minimum of 30 minutes operation following a mains supply failure.

8.9.9 Application programs and database of dynamic positioning control system programmable devices shall be protected against destruction or data loss due to faults in the equipment power supply system.

8.10 POSITION REFERENCE SYSTEMS

8.10.1 Position reference systems for Class 1 DP-systems shall be based on the operating requirements with due regard to the acceptable performance characteristics.

8.10.2 For Class 2 and 3 DP systems, at least three independent position reference systems, based on different principles, which shall be simultaneously and coordinately available to the DP-control system during operation, shall be installed.

8.10.3 The position reference systems shall produce data with adequate accuracy. Provision shall be made for visual and audible alarm to indicate deviations from true data or excessive degradation of the signals from the position reference systems.

8.10.4 For Class 3 DP systems, one of the position reference systems shall be connected to the back-up control system and located in a space separated by "A-60" class bulkhead from the spaces containing other position reference systems.

8.11 EXTERNAL FORCE SENSORS

8.11.1 For the DP systems, provision shall be made for at least the following external force sensors determining:

heading;

magnitude of ship motions;

wind speed;

wind direction.

8.11.2 For Class 2 or 3 DP systems where required accuracy of keeping ship's position or heading is fully dependent on correct signals from external force sensors, at least three independent external force sensor systems shall be available for each parameter (e.g. three gyro compasses shall be provided for heading).

8.11.3 For Class 3 DP systems, one group of sensors of each type, in addition to the requirements set forth in **8.11.2**, shall comply with the requirement for separation thereof by "A-60" class bulkhead from other sensors.

8.12 ALARM AND MONITORING SYSTEM

8.12.1 In addition to the requirements set forth in **2.4**, the alarm and monitoring system shall be arranged with facilities to preserve and indicate the data on failure alarms and change in their state.

8.12.2 Parameters monitored by the alarm and monitoring system shall be subdivided structurally into parameters, which to a certain degree are informative, and parameters, which when alarmed require immediate actions to be taken by the personnel.

The list of parameters is given in Table 8.12.2.

Table 8.12.2

Parameter	Alarm	Comments
Computer-based control system	Failure[1]	Automatic change-over to back-up system
Heading	Deviation beyond permissible	—
Position on station	Deviation beyond permissible	—
Power supply system	Failure	Automatic change-over to back-up system
Position reference installation	Failure Error Customizing nonconformity	For each position reference system
Gyrocompass	Error Non-conformity	Automatic change-over to stand-by compass
Position reference system	Error Non-conformity	Automatic change-over to back-up system
Wind pressure sensor	Error Non-conformity	Automatic change-over to back-up sensor
Oil pressure in the hydraulic system "Taut wire"	Minimum	The alarm system parameters may be integrated
Oil temperature in the hydraulic system "Taut wire"	Maximum	Ditto
Oil tank level in the hydraulic system "Taut wire"	Minimum	Ditto

Deviation signal of the hydraulic system "Taut wire"	Limiting deviation	—
Total electric power consumption	Excess	Adjustable within 50-100%
Air temperature of the air conditioning system for computers	Maximum	—
Serviceable condition of main units (sub-systems)	Change in state	—
[1] The computer-based system shall be able to use the last information on position in case when one or more position reference systems are failured or not switched on.		

8.13 CABLE ROUTEING AND PIPING OF DP-SYSTEM MACHINERY AND DEVICES

8.13.1 For Class 1 and 2 DP systems cable routes of electrical equipment and control systems, as well as hydraulic, fuel and lubricating oil and other piping shall be installed with due regard to the requirements set forth in **16.8.4**, Part XI "Electrical Equipment" and Section **5**, Part VIII "Systems and Piping".

8.13.2 For Class 3 DP systems, cables of stand-by electric and electronic equipment and piping of stand-by support systems and control systems shall not be routed together with cables and piping systems of the main equipment through the same spaces (compartments).

Such installation may be only accepted in cases when the cables of stand-by equipment and, in turn, piping of stand-by systems run in "A-60" class fire-protective ducts. Use of cable connection boxes is not allowed in fire-protective ducts.

9. POSITION MOORING SYSTEMS

9.1 SCOPE OF APPLICATION

9.1.1 The requirements of this Section apply to the automated control systems of power equipment of position mooring systems.

9.1.2 Compliance with the requirements of this section and the applicable requirements of other sections of this part is mandatory for ships equipped with position mooring system, with signs **POSMOOR** or **POSMOOR -TA** added to the class notation in accordance with the **2.2.10**, Part I "Classification".

9.2 DEFINITIONS AND EXPLANATIONS

9.2.1 *Position mooring system* means a complex of systems, machinery and equipment intended for the ship's position keeping at predetermined accuracy when exposed to external disturbing forces by means of tensile anchor lines.

9.2.2 *Auxiliary thrusters-assisted position mooring* means the use the ship's main propulsion plant and thrusters together with the position mooring system.

9.3 CONTROL SYSTEMS

9.3.1 Each anchor winch shall be provided with the independent control system supplied by its own feeder with an individual protective device.

9.3.2 Each winch shall have a control station located so as to provide a good view of the anchoring operations having regard to the laying-out of the anchor by an anchor handling vessel.

9.3.3 Means shall be provided at each anchor winch control station to monitor chain cable/rope tension, the winch load (current) and the length of the chain cable/rope paid out, the chain cable/rope paying out speed.

9.3.4 A manned anchoring operations control station shall be provided with means to indicate chain cables tension, wind speed and direction.

Besides, it shall be provided with means of communication between all control stations critical to anchoring operations.

9.3.5 The local and remote control stations shall be provided with the emergency anchor release arrangements that remain operable at the loss of power supply from the main source of electrical power by automatic switching to the standby source of power. The above controls need not be supplied from the independent source of power.

9.3.6 The emergency release arrangements shall actuate at a load equal to the minimum design tensile strength of the chain cable/rope, as well as at the maximum possible angles of heel and trim as regards damage stability and flooding conditions.

9.3.7 The following alarm signals shall be provided at the central and local anchoring operations control stations:

on excessive chain cable/rope tension,

on decrease of the chain cable/rope tension below the permissible limits.

9.3.8 Alarms shall be provided at the central anchoring operation control station on the ship's leaving the positioning point and on the ship's deviations from the set course. The possibility shall be provided of the settings adjustment of the alarms actuation within the specified limits.

Actuation settings shall be clearly identified.

Measures shall be taken against inadvertent/ unintended resetting.

9.4 AUXILIARY THRUSTERS FOR ANCHORING SYSTEMS

9.4.1 Where the anchoring systems are used in conjunction with auxiliary thrusters to keep the ship position, the latter shall comply with the requirements of Chapter **8.7**.

9.4.2 Applicable requirements for dynamic positioning systems set forth in **8.7** and **8.8** cover also auxiliary thrusters control systems including centralized microprocessor control units.

9.4.3 Input signals fidelity of the auxiliary thrusters control system shall be provided by the signals relevant processing.

All errors revealed during the fidelity check shall actuate alarms.

PART XIII. MATERIALS

1. GENERAL

1.1 APPLICATION

1.1.1 The requirements of this Part of the Rules apply to materials and products that are subject, in conformity with the other parts of the Rules, to the survey by the Register.

Requirements pertaining to the choice and application of materials and products shall be found in the relevant parts of the Rules.

Requirements to the scope of survey and testing at the initial survey of manufacture of materials and products, as well as at carrying out of the Register technical supervision in course of their manufacture are stipulated in Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

1.1.2 Unless specified otherwise, materials and products shall meet the requirements of this Part of the Rules.

1.1.3 Materials, being part of a structure or product, on which the requirements not included in this Part are imposed, due to conditions of their operation, as well as materials not regulated by this Part, the chemical composition, mechanical and service properties of which were not considered by the Register for a particular application, shall be considered by the Register on the basis of the normative documentation, calculation and test results. These shall confirm the construction or product safety level to be not lower that it is required by the corresponding Sections of the Rules. Requirements for technical supervision of metallic materials are specified in **2.4.1.3** of Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

Materials manufactured according to international and national standards or specifications, or other technical documentation may be permitted by the Register for a specific application, provided the requirements of the Rules are followed.

The Register may permit the delivery of materials and products only in accordance with to the normative technical documentation reviewed by the Register. Given the distinctions between the above documentation and the Rules, materials testings and their assessment shall be carried out taking into account the most strict requirements.

1.1.4 Type of technical supervision of materials and requirements for manufacturers in each case of application are determined in accordance with the Nomenclature of Items of the Register Technical Supervision (see Appendix 1, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships).

1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of the Rules are given in General Regulations for Technical Supervision and Part I "Classification"[1].

For the purpose of this Part the following definitions have been adopted:

Recognized laboratory means a laboratory (center) included into the List of laboratories (centers) having Recognition Certificates of Testing Laboratories.

Recognized enterprise is an enterprise included in the list of recognized (approved) materials and manufacturers.

Product - for the purpose of this Part, semi-finished products, chain cables and accessories, and ropes as well.

Acceptance (certification) tests mean a test extent established by the Register rules or documentation agreed upon by the Register for the products delivered under survey by the Register; the test results serve the basis for issue of the Register certificates.

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[1] Hereinafter - Part I «Classification».

Z-steel is steel with guaranteed through-thickness properties, which is intended for welded structures and can withstand considerable stresses perpendicular to the plate surface.

A specimen is a test piece of specified shape and size prepared from a sample and used for the determination of mechanical, technological and other properties of material by testing.

Register stamp means a brand, stamp or punch of a certain type specified by the Register applied to finished products, or to products during their manufacture, to confirm the fact of survey by the Register and identify the products with the documents issued for them.

A specimen is a test piece of specified shape and size prepared from a sample and used for the determination of mechanical, technological and other properties of material by testing.

Approval of quality system means an action of the Register, certifying that the properly identified quality management system complies with the Register requirements.

A batch is the limited number of semi-finished products and products, to which the results of statutory tests are extended.

Initial tests mean a particular scope of control tests specified in a special program approved by the Register and performed during the works survey exercised by the Register prior to issue of the Recognition Certificate for Manufacturer to the works.

A sample is a portion of a semi-finished product or product or a specially fabricated blank of which test specimens shall be machined.

Recognition Certificate for Manufacturer means a document confirming the compliance of the manufacturer's products and conditions of their manufacturer with the Register rules and warranting the introduction (entry) of the works into the List of recognized materials and manufacturers.

Manufacturer's Certificate means a document of the works certifying the compliance of a particular volume of the specific type of product with the requirements of the order and confirming that the products are manufactured in compliance with production practice adopted at works.

The Manufacturer's Certificate is issued by the manufacturer and shall be certified by signature of the person representing the Quality Control Department.

Type Approval Certificate means a document confirming the compliance of the products manufactured by the enterprise with the requirements of the Register Rules and which guarantees the inclusion of the enterprise in the list of approved (recognized) materials and manufacturers.

Register Certificate (Certificate) means a document certifying the compliance of a particular volume of the specific type of product with the requirements of the Register. The certificate is issued by the surveyor of the Register when supervising the manufacture of products.

Quality system certification means the action of the Register or another organization authorized by the Register, which certifies that the necessary assurance is provided that a properly identified system of the Organization meets the requirements of international standards ISO 9000 series or relevant national requirements.

Lamellar tearing is breaking of welded structure components, made of rolled plates or pipes, due to considerable welding stresses and/or external loads applied in the direction perpendicular to the plate surface.

1.3 SCOPE OF SURVEY

1.3.1 General.

1.3.1.1 General provisions, regulating the scope and the procedure of survey shall be found in the General Regulations for the Classification and Other Activity.

1.3.1.2 If the recognition of manufacturer is required by the chapters of this Part of the Rules, such recognition shall be performed prior to commencement of manufacture of products. For this purpose the Register carries out survey of the works, which comprises the following:

.1 review and recognition of technical documentation specifying the properties and conditions of production.

Review of technical documentation on materials and products, as a rule, is carried out prior to the testing of materials;

.2 direct survey of production and the quality system of the firm, conducting of check testing.

In course of taking the above actions, a compliance of the manufacture parameters and the products with the requirements of the documentation shall be confirmed (refer to 1.3.1.2.1) and the Rules of the Register, as well as the appropriate level of quality stability;

.3 issue of the survey results:

issue of the Recognition Certificate for Manufacturer or Type Approval Certificate (if the results are satisfactory);

preparation of the conclusion on impossibility of issue of the above mentioned Register documents (if the results are unsatisfactory).

All the procedures necessary for obtaining the Recognition Certificate for Manufacturer and Type Approval Certificate and the documents, confirming the recognition of the firm and its products by the Register shall be executed in accordance with the requirements of Sections **2** and **3**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships based on the requests of firms.

1.3.1.3 During production the survey of materials and products in course of the technical supervision includes the following:

.1 tests and inspection;

.2 issue of the documents (refer to 1.4.3) on the basis of the results of tests and inspection.

1.3.2 Testing.

1.3.2.1 Check testing in course of the firm recognition is carried out according to the program approved by the Register. The program is compiled on the basis of the respective requirements of this Part of the Rules, national or international standards and other technical documentation.

Testing under the Register technical supervision during manufacture of products shall be conducted in compliance with the requirements of the chapters of this Part depending on the materials and products subjected to the tests and/or the standards and specifications recognized by the Register.

1.3.2.2 The site and time of the prescribed tests shall be specified by the manufacturer in advance. Sampling, test procedures, specimen cutout procedures shall be effected in compliance with the applicable requirements of the Rules (according to Section 2).

Unless otherwise specified, the Register's representative shall brand the samples and specimens and the tests shall be carried out in his presence.

1.3.2.3 Where the test results are unsatisfactory, unless otherwise specified in the relevant chapters, retesting shall be conducted with the following conditions being observed:

1.3.2.3.1 Tensile test.

From the semi-finished product, which has failed the test, a double number of specimens may be machined from the locality nearest to the area, from which samples have been originally cut out.

In case the results of tests carried out on this double number of specimens are satisfactory, the semifinished product submitted to tests, as well as the relevant batch may be accepted.

If at least one specimen (from the additional set) yields unsatisfactory results, the semi-finished product submitted shall be rejected. However, the Register may accept the rest of the batch, provided the test results obtained on two other semi-finished products of the same batch prove satisfactory.

If one of two semi-finished products selected additionally yields unsatisfactory results, the whole batch shall be rejected;

1.3.2.3.2 Impact test.

The cases of unsatisfactory test results include:

when the average value of three impact tests (KV) fails to meet the prescribed requirements,

or more than one result out of three is below the required average value,

or the result on any one of the specimens is more than by 30 % below the required average value.

In any one of the cases listed, re-testing may be carried out on additional number of specimens machined from the same semi-finished product at the locality nearest to the area of preceding cutting-out.

The submitted semi-finished product and the batch may be accepted if the new average value of test results (three initial tests plus three additional tests) exceeds the required average value and not more than two results out of six are below the required average value and not more than one specimen has yielded the result, which is below the required one by 30%.

Where the results of re-testing of the semi-finished product representing a batch are unsatisfactory, this product shall be rejected, but the remaining semi-finished products of the batch may be accepted in case where the results of tests carried out on two additional semi-finished products of this batch are satisfactory.

Where the test results of two additional semi-finished products are unsatisfactory, the batch shall be rejected. The mentioned additional semi-finished products shall be the thickest among the products available in the batch.

The test principle proposed here for KV may be applicable to U-notched specimen;

1.3.2.3.3 Where the test results are unsatisfactory due to local defects in the specimen material, faulty machining or faulty test equipment or in case of tensile test fracture occurs beyond the design length of the specimen, the test shall be repeated on the same number of specimens.

At the manufacturer's discretion, the semi-finished products from the batch rejected may be submitted to tests item-by-item and where the results are satisfactory, they may be accepted by the Register for supply.

At the manufacturer's discretion, the semi-finished products from the batch rejected may be re-tested after heat treatment, repeated heat treatment, or may be submitted as a category other than that initially declared.

Where test results in case of such repeated submission are satisfactory for supply, the Register may accept the material.

Any material that yielded unsatisfactory results during subsequent machining or application shall be rejected irrespective of the availability of records of tests carried out previously or appropriate certificates.

1.3.2.4 If confusion of specimens or test results is detected or the test results do not make it possible to assess the material properties with the required degree of accuracy, the Register may require any tests to be repeated in the presence of its representative.

1.3.2.5 Material produced, the properties of which do not fully agree with the requirements of this Part, the deviations being not essential for the operation of the structure or product, may be used in accordance with the purpose only subject to review of the deviations by the Register and in case a relevant application from the manufacturer and agreement of the customer is available.

1.4 MARKING AND DOCUMENTATION

1.4.1 Identification.

During manufacture of materials and products at works, the system of monitoring shall be applied, which enable to check the products manufacture at any stage, beginning from the original ladle of metal.

Documentation confirming the availability of such a system at the works shall be submitted to the Register.

1.4.2 Marking.

Prior to submission to the Register representative the materials shall be respectively marked. The marking of the materials, unless specified otherwise, (the peculiarities of marking shall be agreed in advance and shall reflect the particular products properties, for example, refer to **3.2.9**), shall be carried out according to the standards taking the following requirements in consideration:

.1 in the case of semi-finished products delivered in single pieces each one of them shall be marked. For shipments in bundles two weather-resistant labels containing the marking shall be provided and firmly fastened to the opposite ends of the bundle.

When a great number of semi-finished products is delivered and these are of small size, the marking procedure and the content of the marking shall be agreed with the Register.

Semi-finished products to undergo further machining shall be stamped, as far as possible, in spots shall not be machined.

The stamp shall stand out clearly and be framed with a bright paint resistant to atmosphere;

.2 as a rule, the stamp shall include the following information:

grade or quality of material;

figures or other designation to indicate the origin of the semi-finished product (number of semifinished product, number of cast and the like);

manufacturer's name or trade mark;

stamp of the quality control service of the manufacturer's;

Register's brand (if required);

.3 if the semi-finished product does not withstand the tests required by the Rules or defects are revealed, which make its use in accordance with the purpose impossible, the Register brand and the material grade designation shall be removed or cancelled.

Additional requirements to marking are stated in **2.4.3**, Part III "Technical supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

1.4.3 Documentation.

Every batch of the metallic materials and products, or a separate semi-finished product and a separate item, if the delivery is performed in single pieces, which passed the tests, shall be accompanied by the Register certificate or the manufacturer's document certified by the Register representative.

1.4.3.1 Manufacturer's Certificate.

The Register representative simultaneously with the submission of the final material or in advance shall be presented with the Manufacturer's Certificate for Material.

The Certificate shall be attested by the works quality division, witnessed by the authorized person, and, as minimum, shall contain the following data:

name of the works and the order number;

project number, if known;

name, number, dimensions and mass of the semi-finished product with indication of the drawing number or sketch (if applicable);

mark (grade) of the material, type of alloy, number of ladle and chemical composition;

identification number;

type and mode of heat treatment (if necessary);

mechanical test results;

non-destructive testing results (satisfactory or unsatisfactory), if applied.

1.4.3.2 The Register Certificate, at least, shall contain the following data:

order number; building project, if known;

name, number, dimensions and mass of the material;

mark (grade) of the material and condition of supply;

number of Manufacturer's Certificate;

number of batch or semi-finished product or identification number, which enables to identify the supplied material;

drawing number (if applicable).

The obligatory supplement to the Register certificate shall be the Manufacturer's Certificates attested by the authorized representative of the Manufacturer.

If the material is supplied only with the Manufacturer's Certificates, attested by the Register representative, its form and contents shall be agreed with the Register and the purchaser.

1.5 LABORATORIES ENGAGED IN TESTING

1.5.1 This Chapter applies to laboratories engaged in testing of materials subject to the survey by the Register.

1.5.2 Testing of materials provided under the technical supervision of the Register by the recognized metallurgy works (holding the Recognition Certificate of Manufacturer) may be conducted without obtaining a Recognition Certificate of Testing Laboratory by the said laboratories.

The protocols or test reports of these laboratories are sufficient basis for entering data on the chemical composition, mechanical and other properties in the material certificate.

Laboratories of other firms or independent laboratories may determine chemical composition and conduct tests to determine mechanical and other properties of the items of supervision only after being recognized by the Register.

1.5.3 The requirements, specified in **1.5.2**, fully apply to the laboratories engaged in testing of items of the Register supervision by non-destructive methods.

1.5.4 Laboratories engaged in non-destructive testing of materials and products shall have a Recognition Certificate issued by the Register and/or any other appropriate document of the authorized national or international organization, which confirms the competence of the laboratory. In the Certificate or the document the scope and conditions of applying testing shall be defined. To be recognized for applying the ultrasonic testing, a request shall be forwarded to the Register supplemented by the following documents confirming that the laboratory is ready to carry out the non-destructive testing:

documents in confirmation of availability of qualified personnel together with the name of the body having carried out the certification of the personnel;

technical characteristics of relevant equipment and the scope of its application;

instructions for personnel.

Tests shall be made to confirm reliability of the test results and the possibility of their reproduction.

The test program shall be approved by the Register.

1.5.5 The results of material testing and investigations conducted are recorded in the prescribed way (entered in the test log, report, etc.). The test log (report, etc.) shall contain all the data necessary for the assessment of material quality and subsequent issue of certificate.

A report of testing of products shall include at least the following information: kind of product, material and major dimensions of product, testing method, testing frequency, type of unified reference block, size and position of defects, name of operator and date of testing.

2. PROCEDURES OF TESTING

2.1 GENERAL

2.1.1 The requirements of this Section cover the types and procedures of testing materials, which are subject to survey by the Register during their manufacture.

The need to conduct the tests and evaluation criteria of test results are defined in the relevant sections of this Part or other parts of the Rules.

2.1.2 The Section gives general requirements for testing conditions, types and dimensions of test specimens, and their preparation.

Alternative testing procedures and types of test specimens may be adopted, subject to approval of the Register and on condition that they provide adequate accuracy, reproducibility and dependability of tests carried out for determination of material properties required by the Rules.

2.1.3 Types and procedures of special tests for the materials intended for specific use and evaluation criteria, if no instructions are contained in the Rules, shall be agreed with the Register.

2.1.4 When tests are carried out, the requirements of the standards or other regulating documents approved by the Register shall be met.

2.1.5 Samples, from which test specimens are cut shall have undergone the same treatment as the material, from which they have been taken (e.g. heat treatment).

Test specimens shall be prepared in such a manner that properties of the material are not affected.

2.1.6 All the tests shall be carried out by competent personnel on testing machines of adequate capacity being maintained in the appropriate operating condition. The measurement accuracy of testing machines shall be within ±1 %.

The machines shall be regularly, as a rule at least once per year, checked and calibrated by the duly designated national authorities.

The results of regular checks shall be submitted to the Register.

Charpy machines for impact tests shall be verified in accordance with the requirements of ISO 148-2 or another standard recognized by the Register.

Machines for tensile/compression tests shall be verified in accordance with the requirements of ISO 7500-1 or relevant ISO or EN standards or another standard recognized by the Register.

2.2 TESTING PROCEDURES FOR METALS

2.2.1 Testing temperature.

The temperature of the ambient air during the tests shall comply with the requirements of the standards unless expressly provided otherwise in the subsequent sections and chapters of this Part.

2.2.2 Tensile tests.

2.2.2.1 When carrying out tensile tests at the ambient temperature the following tensile properties of metals shall be determined:

.1 yield stress R_e is the value of stress measured at the commencement of plastic deformation at yield or the value of stress measured at the first peak obtained during yielding even when that peak is equal to or less than any subsequent peaks observed during plastic deformation at yield.

Elastic stress rate shall be within the limits specified in Table 2.2.2.1.1.

Table 2.2.2.1.1

Modulus of elasticity of the material E, N/mm^2	Stress rate, N/mm^2 s^{-1}	
	min	max
< 150000	2	20
≥ 150000	6	60

.2 when no well defined yield phenomenon exists, the 0,2 % proof stress $R_{p0,2}$ shall be determined according to the applicable specification.

For austenitic and duplex stainless steel products the 1 % proof stress R_{p1} may be determined in addition to $R_{p0,2}$.

The stress rate shall be as stated in **2.2.2.1.1**;

.3 tensile strength R_m is the value of stress corresponding to the maximum strain rate directly before the test specimen fractures.

To determine the tensile strength R_m the test specimen is subjected to extension up to the fracture by the continuously rising strain rate. After reaching the yield stress or proof stress, for ductile material the machine speed during the tensile test shall not exceed that corresponding to a strain rate of 0,008 per second.

For brittle materials, such as cast iron, the stress rate shall not exceed 10 N/mm^2 per second;

.4 fracture elongation A is the ratio of an increment of the gauge length after fracture to the original gauge length, expressed in %.

The elongation value is, in principle, valid only if the distance between the fracture and the nearest gauge mark is not less than one third of the original gauge length (L_0). However, the result is valid irrespective of the location of the fracture if the elongation value is equal to or greater than the expected value.

Elongation A_5 is usually determined on the small proportional test specimens.

A_0 is determined on the non-proportional test specimens, for instance, with a gauge length L=200 mm and calculated by the formula

$A = 2A_5(\sqrt{S_0}/L_0)^{0,4}$, %.

Non-proportional test specimens are usually used for ferritic type steels of low and medium strength made without application of cold working;

.5 fracture reduction in area Z is the ratio of the difference between the original and the minimum cross-sectional areas of the test specimen after fracture to the original cross-sectional area, expressed in per cent. It is determined for test specimens of circular cross-section;

.6 when tensile tests are carried out at an elevated temperature, the test temperature shall be indicated by the inferior figure, for instance, $R_{m/350}$, $R_{eL/350}$, $A_{5/350}$, Z_{350}, where the number 350 is the test temperature in degrees Celsius.

2.2.2.2 For determination of the test specimen dimensions the following symbols are used, mm:

d – diameter of the parallel test length;

a – thickness of the parallel test length;

b – width of the parallel test length;

L_0 – gauge length;

L_c – parallel test length;

R – transition radius;

S_0 – cross-section;

D – external tube diameter;

t – rolled products thickness.

2.2.2.3 Tensile tests shall be carried out on the test specimens of the following types (refer to Fig. 2.2.2.3):

Test specimens of rectangular cross-section with a gauge length equal to $L_0 = 5,65\sqrt{S_0}$ or of circular cross-section with a gauge length $L_0 = 5d_0$ are called proportional test specimens.

Proportional test specimens are preferable for tensile tests. The minimum elongation values given in this Part are specified for these specimens. The gauge length L_0 of the specimen shall preferably be greater than 20 mm.

The value of the specimen gauge length after its measuring may be rounded off to the nearest 5 mm, provided that the difference between this length and L_0 shall be less than 10 % of L0.

Tensile tests for flats up to 40 mm thick shall be carried out with flat specimens of full thickness. It is allowed to reduce the specimen thickness by machining one of the rolled surfaces. The specimen thickness reduction shall be caused by the insufficient capacity of a testing machine.

Tests shall be carried out on the specimens according to Table 2.2.2.3.

Test specimens for a tensile test, as a rule, shall be cut out so that their longitudinal axes were aligned with the metal basic deformation. Test specimens may be cut out transverse if there is the relevant instruction in sections of this Part. During the works initial survey the rolled plates can be tested using both the longitudinal and transverse test specimens.

2.2.2.4 For the determination of tensile strength R_m of nodular cast iron, test specimens of circular cross-section shown in Fig. 2.2.2.4 shall be used.

2.2.2.5 Flat specimens shall be used in tensile tests of semi-finished products of wrought aluminium alloys for thicknesses up to and including 12,5 mm. The tensile test specimens shall be prepared so that both rolled surfaces are maintained. For semi-finished products over 12,5 mm thick, round tensile test specimens are used. Test specimens from semi-finished products up to 40 mm thick are cut out so that their axis is located in the middle of the thickness. Test specimens from semi-finished products over 40 mm thick are cut out so that their axis is located at a distance from one of the surfaces equal tone quarter of the thickness.

2.2.2.6 When wire is tested, its specimens of full cross-section shall be of the following dimensions:

L_0 = 200mm,

$L_c = L_0$ + 50mmm.

Table 2.2.2.3

Semi-finished product	Specimen type	Specimen dimensions
Plates, strips, sections	Fig. 2.2.2.3,***a*** Fig. 2.2.2.3,***в***	**Proportional round specimens** $10 \le d \le 20$, for deposited metal d = 10, preferably;; $L_0 = 5d$; $L_c = L_0 + d$. R = 10 (for materials with $A_5 \le 10$ %, $R \ge 1{,}5$ for nodular cast iron). The axes of the round test specimens shall be located at approximately ¼ of the thickness from one of the rolled surfaces. For rods and products of small dimensions, on agreement with the Register, test specimens of full thickness and with relevant other dimensions may be used. $L_c = L_0 + d$
Plates, strips, sections	Fig.2.2.2.3,***b***	**Proportional flat specimens** $a = t$ (t - plate thickness); b = 25; $L_0 = 5{,}65\sqrt{S_0}$; $L_c = L_0 + 2\sqrt{S_0}$; R = 25 for plate thickness t equal to or less than 12,5 mm the specimens may be allowed $b = 2t$, $R = 2t$ or: **Non-proportional flat specimens** a = plate thickness; b = 25; L_0 = 200; $L_c \ge 212{,}5$; R = 25. For materials over about 40 mm thick, proportional round test specimens with dimensions as specified in Fig. 2.2.2.3 (a) may be used. It is recommended to use specimens with following dimensions: d = 14; $L_0 = 5d$; $L_c \ge l_0$+d/2 When the capacity of the available testing machine is insufficient to allow the use of test specimen of full thickness, this may be reduced by machining one of the rolled surfaces.
Tubes	Fig.2.2.2.3,***d*** Fig.2.2.2.3,***e***	**Full cross-section specimen with plugged ends** $L_0 = 5{,}65\sqrt{S_0}$; $L_c = L_0 + D/2$, where L_c is the distance between the grips or the plugs, whichever is the smallest; **Strips cut longitudinally** $a = t$; b = 12; $L_0 = 5{,}65\sqrt{S_0}$; $L_c = L_0 + 2b$; Round test specimens may also be used provided that the wall thickness is sufficient to allow the machining of such specimens to the dimensions as specified in Fig. 2.2.2.3 (a) with their axes located at the midwall thickness

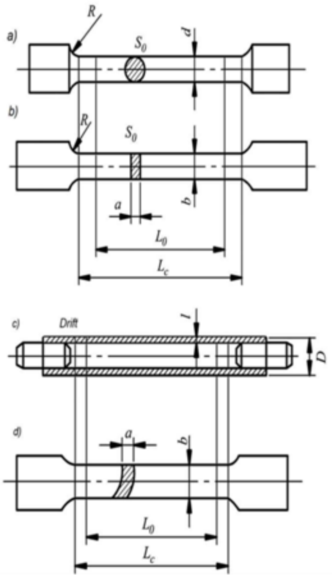


Fig. 2.2.2.3

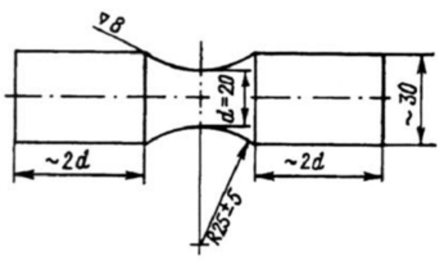


Fig. 2.2.2.4.

2.2.2.7 Through thickness tensile tests shall be carried out on test specimens the longitudinal axis of which is perpendicular to the rolling surface (direction Z, refer to Fig. 2.2.2.7-1).

Test procedures and dimensions of the round specimens shall comply with the national and international standards recognized by the Register.

The testing scope is given in **3.14.4**.

For plates and wide flats, one test sample shall be taken close to the longitudinal centreline of one end of rolled piece representing the batch as shown in Fig. 2.2.2.7-2.

The sample shall be large enough to accommodate the preparation of 6 specimens. 3 test specimens shall be prepared while the rest of the sample remains for possible retest.

The test is considered invalid and further replacement test is required if the fracture occurs in the weld or heat affected zone.

2.2.2.8 In weldability tests (refer to 2.4) tensile test specimens shall have the following dimensions:

For deposited metal tensile test:

d = 10mm;

L_0 = 50mm;

$L_C \geq$ 55mm;

$R \geq$ 10mm.

When necessary, the specimens of other dimensions may be used; the geometrical relationship of the above parameters therewith shall be observed;

for butt-weld tensile test (refer to Fig. 2.2.2.8):

$a = t$;
b = 12mm for $t \leq 2$mm;
b = 25mm for $t > 2$mm;
L_C = width of weld + 60mm;
$R \geq 25$mm.

The upper and lower surfaces of the flat specimen weld shall be machined flush with the surface of the base metal.

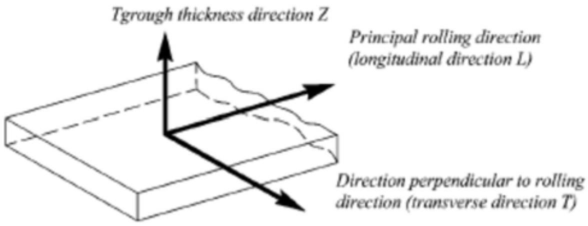


Fig. 2.2.2.7-1

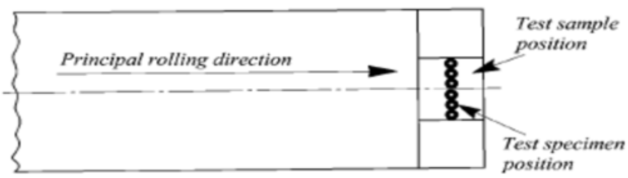


Fig. 2.2.2.7-2

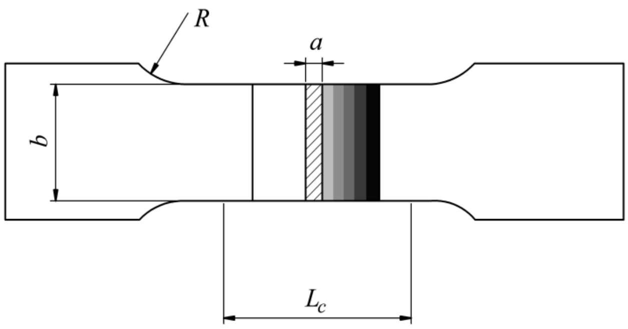


Fig. 2.2.2.8

2.2.2.9 The tolerances on specimen dimensions given in **2.2.2** shall be in accordance with ISO 6892-84.

If made according to the standards recognized by the Register, the specimen deviations shall comply with these standards.

2.2.3 Impact tests.

2.2.3.1 The impact toughness KCU shall be determined on Charpy U-notch type test specimens as in Fig. 2.2.3.1-1 and Table 2.2.3.1-1, the impact energy KV and KU on Charpy V-notch type test specimensand Charpy U-notch type test specimens as in Figs. 2.2.3.1-2 and 2.2.3.1-3, and Tables 2.2.3.1-2 and 2.2.3.1-3.

The impact tests shall be carried out on Charpy machines complying with the requirements of ISO 148 or other national or international standard recognized by the Register, and having a striking energy of not less than 150 J. Where the test temperature is other than ambient, the temperature of the text specimen at the moment of breaking shall be the specified temperature within ±2°C.

The impact energy KV and KU is determined as an average value obtained at testing three specimens.

required mean values of the impact energy depending on the dimensions of the specimens selected for tests (E is the required minimum value of impact energy) are given in Table 2.2.3.1-4. The result of tests on one of the specimens therewith may be less than that given in Table 2.2.3.1-4, but its value shall not be less than 70 % of the required one.

Table 2.2.3.1-1

Dimensions	Nominal	Tolerance
Length *L*, mm	55	±0,60
Width *b*, mm	10	±0,10
Thickness *a*, mm	10	±0,10
Root radius *r*, mm	1	±0,10
Distance of notch from end of test specimen *L/2*, mm	27,5	±0,40
Angle between plane of symmetry of notch and longitudinal axis of test specimen θ, °	90	±2

Table 2.2.3.1-2

Dimensions	Nominal	Tolerance
Length *L*, mm	55	±0,60
Thickness *a*, mm	10	±0,10
Width *b*, mm	10 7,5 5,0	±0,10 ±0,10 ±0,06
Angle of V-notch γ, °	45	±2
Depth of notch *h*, mm	8	±0,06
Root radius *r*, mm	0,25	0,025
Distance of notch from end of test specimen *L/2*, mm	27,5	±0,040
Angle between plane of symmetry of notch and longitudinal axis of test specimen θ, °	90	±2

Table 2.2.3.1-3

Dimensions	Nominal	Tolerance
Length *L*, mm	55	±0,60
Width *b*, mm	10	±0,11
Thickness *a*, mm	10	±0,11
Depth below notch *h*, mm	5	±0,09
Root radius *r*, mm	1	±0,07
Distance of notch from end of test specimen *L/2*, mm	27,5	±0,42
Angle between plane of symmetry of notch and longitudinal axis of test specimen θ, °	90	±2

Table 2.2.3.1-4

Dimensions of test specimen, mm	Average value of impact energy, J
10 × 10 × 55	1*E*
10 × 7,5 × 55	5/6*E*
10 × 5 × 55	2/3*E*

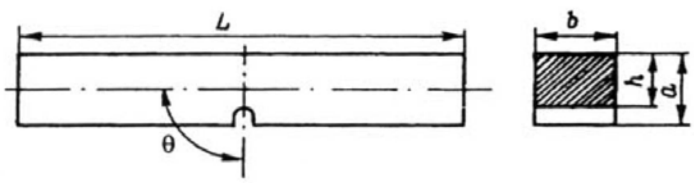


Fig. 2.2.3.1-1

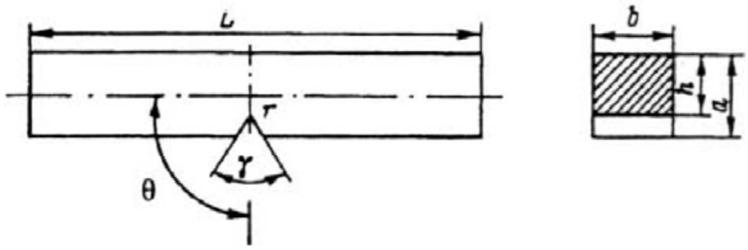


Fig. 2.2.3.1-2

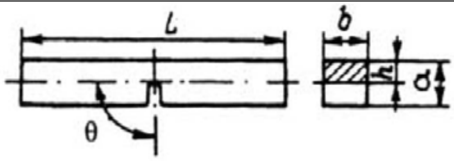


Fig. 2.2.3.1-3

Impact energy KV for the rolled products having thickness *t* of less than 10 mm is determined under test specimens as in Fig. 2.2.3.1-2 with width *b* equal to rolled thickness with no machining of the sides. For welded joints of such rolled products, the impact energy KV is determined on machined specimens of maximum possible thickness considering removal of weld undercuts.

It is recommended to use welded specimens with thickness of b = 7,5, 5 and 2,5 mm.

The required impact value E(*b*) for specimens with width $b < 10$ mm may be calculated based on the required minimum average impact energy for specimens 10 mm wide (E_{10}) using formula:

$$E(b) = (b/15 + 1/3)\,E_{10}, \tag{2.2.3.1}$$

rounding to the whole number in J. The test result for one of the specimens may be lower than the value calculated by the formula in 2.2.3.1.1, but it shall be equal to at least 70 % of the required one.

The tests on the rolled products with thickness of less than 6 mm shall be performed upon the Register request considering the requirements in 3.5. The tests on the rolled products with thickness of less than 2,5 mm shall not be performed.

The impact toughness KCU is determined as an average value obtained at testing two specimens.

In this case, each of the impact toughness values obtained shall not be less than required. Necessity of testing impact toughness of material having a thickness of less than 10 mm as well as corresponding estimation criteria shall be justified in the documentation submitted to the Register.

2.2.3.2 The dimensions of the test specimens without any notch used for impact tests, in mm, shall be as shown in Fig. 2.2.3.2.

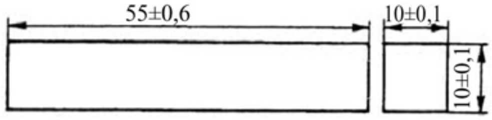


Fig.2.2.3.2

2.2.3.3 Impact tests shall be carried out on Charpy machines having a striking energy not less than 150 J. The distance between the supports shall be 40 ± 0,5 mm. The pendulum shall break the test specimen in the plane of symmetry of the notch and from the side opposite to it, the distance between the plane of symmetry of the notch and that of the pendulum being not in excess of 0,5 mm.

When test temperature is below the room temperature, the test specimens shall be supercooled prior to installing on the Charpy machine. The degree of supercooling shall provide the required test temperature with maximum deviation of ±2°C.

The degree of supercooling shall be determined according to Table 2.2.3.3, if the test specimens are tested maximum 3 to 5 s after removal from the thermostat.

Table 2.2.3.3

Test temperature, °C	**Super-cooling temperature, °C**
Від мінус 100 до мінус 60	- 4 - 6
Від мінус 60 до мінус 40	- 3 - 4
Від мінус 40 до плюс 10	-2 - 3

2.2.3.4 Strain ageing sensibility tests shall be carried out on specimens made of samples selected similar to impact samples. Unless otherwise specified, metal strips from which specimens are cut shall be subjected to extension deformation assuming 5 % residual elongation.

Impact test specimens made of strips subjected to extension deformation are subject to even heating (artificial ageing) up to 250°C, with 1 hour conditioning at this temperature and subsequent cooling in the air.

Impact tests of these specimens shall be carried out at room temperature (within 18 to 25°C) and/or at temperature agreed additionally.

Unless otherwise specified, the hull structural steel strain ageing sensibility tests are required at the initial survey of the manufacturer, at procedure alterations and in doubtful or arguable cases related to the rolled products quality. At the initial survey and at the tests procedure alterations the tests shall be carried out according to the requirements of **1.3.5.3.6**.

In other cases the steel tests as a rule shall be carried out at room temperature and at the impact tests temperature for the submitted steel grade (e.g. -20°C for grade D32 steel).

Unless otherwise specified, the hull structural steel strain ageing sensibility tests results shall comply with the Rules requirements for steel during impact tests (e.g. for grade D32 steel the average value of impact tests results shall not be less than 31 J at -20°C with the steel thickness ≤50 mm - refer to Table 3.2.3).

When the above tests are carried out at temperatures lower than the prescribed for the submitted steel grade (e.g. for grade D32 steel - lower than -20°C), the required average value of tests results is set forth by the steel manufacturer and shall be specified in the documentation submitted to the Register.

2.2.4 Hardness testing.

Hardness shall be determined according to Brinell (HB), Vickers (HV), Rockwell (HRC) or using any other method approved by the Register.

2.2.5 Technological tests.

2.2.5.1 The test specimens cut as shown in Fig. 2.2.5.1 shall be used for bend test.

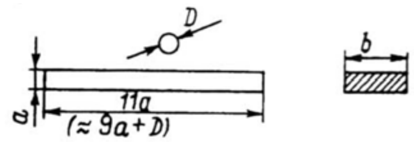


Fig. 2.2.5.1

Edges of the specimens on the tension side may be rounded to a radius of 1 to 2 mm.

The mandrel diameter and the angle of specimen bending is indicated in the relevant chapters of the Part.

The bend test of plates and sections, and also the test of welded transverse specimens (both sides) shall be carried out on the test specimens of the following dimensions: *a*=*t*; *b*=30 mm, t is the product thickness. Where the thickness of the product exceeds 25 mm, the test specimen may be machined on one side to a thickness of 25 mm. During the test the machined surface shall be on the compression side of the bend test specimen.

The bend tests of forgings, castings and similar semi-finished products shall be carried out on the specimens having the following dimensions: *a*=20 mm, *b*=25 mm.

2.2.5.2 Flattening tests are carried out on specimens (pipe lengths) having a length from 10 mm to 100 mm.

The specimen ends shall be plain and smooth with their cuts perpendicular to the tube axis (ДСТУ ISO 8492 or relevant ISO standard).

2.2.5.3 Drift expanding tests are carried out on specimens made in accordance with the requirements of ДСТУ ISO 8493 or relevant ISO standard (refer to Fig. 2.2.5.3).

For metallic tubes, the specimen length (tube length) *L* is equal to twice the external diameter *D* of the tube if the angle of the drift *β* is 30°, and L is equal to 1,5*D* if the angle of the drift is 45° or 60°.

The test piece may be shorter, provided that after testing the remaining cylindrical portion is not less than 0,5*D*.

The rate of mandrel penetration shall not exceed 50 mm/min.

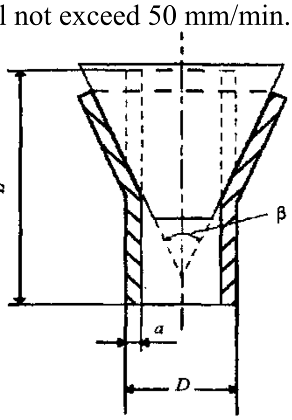


Fig. 2.2.5.3

2.2.5.4 Ring tensile tests are carried out in accordance with the requirements of ДСТУ ISO 8496 or relevant ISO standard.

The length of specimens (tube lengths) is equal to 15 mm and the rate in tests shall not exceed 5 mm/s.

2.2.5.5 Flanging tests are carried out on specimens (tube lengths) having a length of 1,5D in accordance with the requirements of ДСТУ ISO 8494 or relevant ISO standard (refer to Fig. 2.2.5.5).

The test piece may be shorter, provided that after testing the remaining cylindrical portion is not less than 0,5*D*.

The rate of mandrel penetration shall not exceed 50 mm/min.

2.2.5.6 Ring expanding tests are carried out in accordance with the requirements of ДСТУ ISO 8495 or relevant ISO standard (refer to Fig. 2.2.5.6). The length of specimens (tube lengths) may vary from 10 mm to 16 mm and the rate of mandrel penetration shall not exceed 30 mm/s.

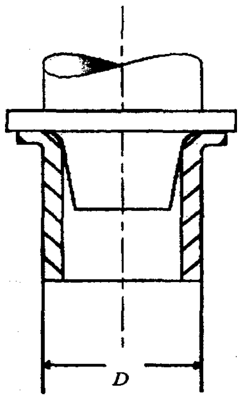


Fig.2.2.5.5

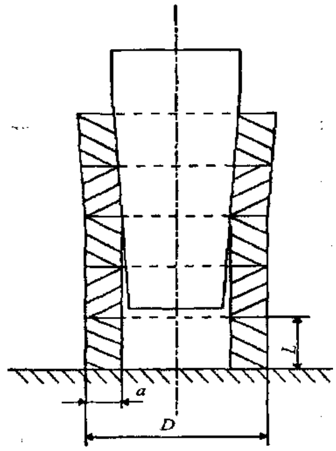


Fig. 2.2.5.6

2.2.6 Dropweight tests for determination of nil-ductility temperature (NDT).

When required by the Rules, dropweight tests and results evaluation are effected in accordance with the ASTM E208 standard and the procedures recognized by the Register.

The tests shall be carried out on the specimens of the following types (dimensions in mm):

Type P-1: 256906360;

Type P-2: 196506130;

Type P-3: 166506130.

The dimensions of specimens are chosen so that their thickness approximates that of the material to be tested.

The following shall be noted, unless otherwise specified:

.1 no warming up of specimens is allowed if they are made by machining (if flame cutting is used, the specimen side shall be at least 25 mm from the cut line);

.2 no machining is allowed for the tensile side of the specimen;

.3 the specimens in the series shall be of the same orientation.

2.2.7 Macro and micro structural analysis.

Коли це вимагає ця частина або інші частини Правил, макро- і мікроструктурний аналіз металевих матеріалів виконується за стандартами.

2.2.8 Chemical analysis.

The methods for determination of chemical composition of metals and permissible deviations are specified in relevant standards.

2.2.9 Non-destructive testing.

2.2.9.1 When radiographic testing is carried out, the results shall be recorded in the form of radiographs with a summary of test evaluations attached.

2.2.9.2 Ultrasonic testing shall be carried out using the pulse-echo methods. For control purposes dualsearch units are used.

To provide for more precise testing, single-dual and prismatic search unit use shall be approved by the Register.

Good condition and accuracy of the test equipment shall be regularly checked. The size of permissible defects and criteria for their estimation are subject to agreement with the Register as a part of design documentation for the product.

The surface of the product shall provide a safe and uniform acoustic contact with the search unit.

The ultrasonic testing is carried out after heat treatment at the stage of manufacture when the product has the simplest shape.

2.2.9.3 For magnetic particle testing only technique proved satisfactory in practice may be used. The material surface under test shall have appropriate intensity of the field.

A need in demagnetization of the product after completion of the test shall be specified in the technical documentation

2.2.9.4 Testing methods other than those referred to in **2.2.9.1 – 2.2.9.3**, as well as the relevant evaluation criteria shall be approved by the Register.

2.2.9.5 The evaluation of non-destructive testing results shall be made only by the works responsible for the results submitted to the Register.

Records of testing shall be appended to the Register certificate in case non-destructive testing is required by the Rules.

2.2.10 The evaluation of non-destructive testing results shall be made only by the works responsible for the results submitted to the Register. Records of testing shall be appended to the Register certificate in case non-destructive testing is required by the Rules.

2.2.10.1 The present procedures may be used in developing and correcting the programs needed in survey of manufacture of steel intended for use at low temperatures (refer to 3.5) including the steel marked with upper index «**Ice**» (refer to **3.5.2.1**). The present provisions apply to: procedures for determining the temperature of a ductile-brittle transition to estimate the material property with regard to retarding the spread of brittle failure (T_{kb}, *NDT*, *DWTT*);

procedures for determining crack resistance parameter *CTOD* for the base metal and the heat-affected zone (HAZ) in testing the specimens cut out from butt-welded joints.

Where one procedure for steel production is concerned (smelting, rolling, condition of supply), the results of tests carried out for the greatest thickness of rolled products may be extended to the rolled products of less thickness.

2.2.10.2 Tests to determine the temperature T_{kb}.

The temperature T_{kb} is defined as the one corresponding to 70 % of a fibrous component in the fracture of a full-thickness radially-notched specimen being broken down in static bending. The specimens shall be dimensioned according to **2.4.2.5**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP.

The tests are carried out for rolled products over 10 mm thick. For rolled products over 70 mm thick the specimens of 70 mm thick cut out in the mid-thickness of rolled products may be tested.

The test procedure shall meet the requirements of **2.4**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP.

2.2.10.3 Tests for determining temperature *NDT*.

The nil-ductility temperature *NDT* is the maximum temperature (determined at 5°C intervals) at which standard specimens with a brittle notched weld deposit break down in impact testing. The test procedure and specimen dimensions shall meet the requirements of **2.3**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP. Refer also to **2.2.6** of this Part.

The tests are carried out for the rolled products having a thickness t over 15 mm of the specimens manufactured in compliance with **2.3.2**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms. The specimens are cut out from a surface. The rolled products surface is considered to be the work surface of the specimen on the side of a weld deposit. In accordance with the program approved by the Register additional specimens shall be cut out as follows:

from the mid-thickness of the plate, in the laminate plane, transversely to the direction of rolling (specimens of types 1 or 2) - for rolled products over 40 mm up to and including 50 mm thick;

for plates of 50 mm thick, specimens of type 2 from the mid-thickness perpendicular to the plate surface so that the direction of breakdown development coincides with that of the rolling.

To reduce plastic deformation, the specimen deflection in testing is restricted with a stopper.

This type of tests for castings and forgings is allowed only according to the procedure agreed with the Register.

2.2.10.4 Tests for determining temperature *DWTT*.

The temperature DWTT shall be determined in drop-weight testing as the temperature corresponding to 70 % of a fibrous component in the fracture of a full-thickness specimen with a sharp notch being broken down in shock loading at a rate of 5 to 8 m/s. The main specimen dimensions: height =75 ± 2mm, length - 300 ± 5mm; space between support - 250 + 2mm.

The tests are carried out for rolled products with thickness equal to 7,5 mm and up to 40 mm according to the procedure agreed with the Register. For rolled products with thickness over 19 mm the specimens with thickness equal to 19 mm cut out from the mid-thickness of rolled products on thickness may be tested. In this case the *DWTT* is higher in comparison with the temperature of full thickness: having rolled products' full-thickness of over 19 mm and above 30 mm at 10°C, having rolled products' thickness of over 31 and above 40 mm — at 15°C.

The test method consists of a bending load applied to the specimen until it collapses with the concentration of one impact by the impactor of the load, which falls, or the copra pendulum. A series of 10 samples are tested at room and reduced temperatures (two samples per temperature) in order to determine the percentage of viscous (brittle) component in the fractures and to build the dependence of "fiber percentage - temperature". As a result, the following is determined:

the temperature at which the specimens satisfy the criterion for a given fraction of the fiber component in the fracture;

average and minimum fraction of fibrous component in the fracture at operating temperature for the tested steel category.

Sample (workpiece) for the manufacture of specimens from the sheet is cut out across to the axis of rolling in 1/4 of the sheet width.

The number of sheets selected for testing shall be at least three, unless otherwise indicated. When cutting out the sample (workpiece) by fire method, the allowance for machining from the cut line to the edge of the sample shall be at least 15 mm.

The prismatic specimens with a notch on the surface to be tensile, from which a crack extends under impact (refer to Fig. **2.2.10.4**), shall be tested. Performance of notches with milling cutter is prohibited. Pressed cuts and chevron saws are allowed. In addition to the percentage of the fiber component, it is advisable to record the energy expended for the destruction of the sample.

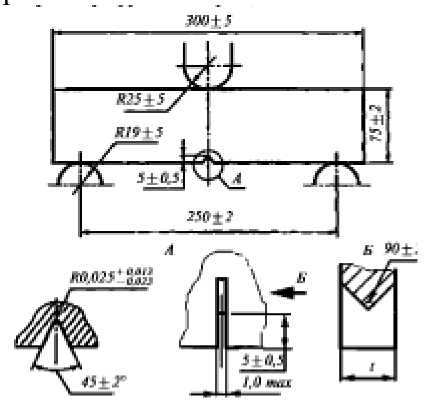


Fig. 2.2.10.4. Sample and tools for testing
(*t*- thickness, all sizes in mm unless otherwise stated).

2.2.10.5 Tests for determining crack resistance parameter *CTOD* for base metal. The crack resistance parameter *CTOD* is defined as the crack tip opening displacement, in mm, with crack appearance under loading conditions for the type of crack propagation. The test is carried out in fullthickness specimens with a sharp notch having fatigue precracking. The tests are conducted for rolled products not less than 25 mm thick according to the procedure agreed with the Register in compliance with the requirements of **2.2**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP.

For the given type of tests, their performance is recommended at temperatures of -30, -40, -50°C. At least three specimens for each temperature shall be tested.

The specimens over 70 mm thick may be tested after their working on one of the sides to a thickness of 70 mm. In this case the test temperature shall be reduced by 5°C as compared to the above mentioned for steel of up to 90 mm thick, and by 10°C for steel over 90 mm thick.

This type of tests for castings and forgings is allowed only according to the procedure agreed with the Register.

2.2.10.6 Tests for determining crack resistance parameter *CTOD* for the HAZ metal.

The tests are carried out similar to **2.2.10.5** using the specimens cut from welded billets with K- or V-preparation to have the front of an initial fatigue crack located in the certain structural component of HAZ.

The tests are carried out for rolled products of not less than 25 mm thick. Procedures for preparing billets, cutting out and marking specimens, testing, and estimating the correctness of the results obtained shall be agreed with the Register and shall meet the requirements of **2.2**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP.

Unless otherwise specified, samples are welded at the maximum heat input specified for a given steel in normative documentation, and the notch shall be marked in the zone of the maximum overheating in welding a large-grain component of HAZ at a distance up to 1 mm from a fusion line.

For the given type of tests, their performance is recommended at temperatures of -30, -40, -50°C. Three correct values, as a minimum, shall be obtained in tests at one temperature.

In case the data scattering is considerable, and the minimum *CTOD* value is less than 0,5 of its average value the number of specimens tested at this temperature shall be increased until 5 correct test results.

The specimens over 70 mm thick may be tested after their working on one of the sides to a thickness of 70 mm. In this case the test temperature shall be reduced by 5°C as compared to the above mentioned for steel of up to 90 mm thick, and by 10°C, for steel over 90 mm thick.

2.3 PROCEDURES OF TESTING NON-METALLIC MATERIALS

2.3.1 Testing conditions.

2.3.1.1 Before testing test specimens shall be conditioned at an ambient air temperature 23 ± 2°C and relative humidity 50 ± 5%. Unless expressly provided otherwise, the duration of conditioning shall be at least 16 h.

Testing shall be carried out immediately after completion of conditioning of the test specimens.

The conditioning may be omitted if it is proved to the Register that testing conditions do not significantly affect the test results and their stability.

2.3.1.2 2 The test specimens of reinforced materials are cut in the warp or weft direction so that the axis of the test specimen shall be parallel to the fibres of warp or weft, respectively.

2.3.1.3 In case of the tests carried out according to the method approved by the Register test, specimens may be used, whose shape and dimensions differ from those required by this Chapter.

2.3.1.4 Testing conditions other than those specified in this Chapter shall comply with the relevant standards.

2.3.2 Tensile tests.

2.3.2.1 Tensile strength of glass-reinforced plastics shall be determined on the test specimens according to Figs. 2.3.2.1-1 and 2.3.2.1-2, and Table 2.3.2.1.

2.3.2.2 The tensile strength and fracture elongation of laminated textiles are determined on test specimens 50 ± 1 mm wide having the original length between the grips of testing machine 200 ± 5 mm.

The pre-load applied is 2 N for cloths with a density 200 g/m^3 or less, 5 N for cloths with a density more than 200 and up to 500 g/m^3 and 10 N for cloths with a density above 500 g/m^3.

The moving rate of the testing machine grips is 100 ± 20 mm/min.

Fracture elongation shall be in accordance with **2.2.2.1.4**.

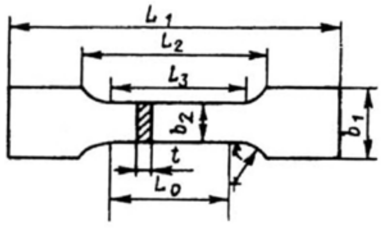


Fig. 2.3.2.1-1

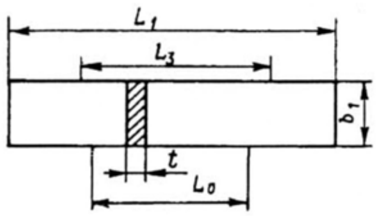


Fig. 2.3.2.1-2

Table 2.3.2.1

Dimensions, mm	Fig. 2.3.2.1-1	Fig. 2.3.2.1-2
L_{1min}	150	250
L_2	115 ± 5	170 ± 5
L_3	60 ± 0,5	–
L_0	50 ± 0,5	50 ± 1
b_1	20 ± 0,5	25 ± 0,5
b_2	10 ± 0,5	–
t	1...10	1...6

r	60	–

2.3.2.3 The tear propagation strength of laminated textiles is determined on rectangular test specimens measuring (225 ± 5) × (75 ± 5)mm.

An incision 80 ± 1 mm long shall be made in the middle of one of the specimen ends parallel to the longitudinal edge. Both the ends of the incised specimen are then fixed in the grips of testing machine so that the area where the tear begins is parallel to the direction, in which the breaking load is applied.

The moving rate of the testing machine grips is 100 ± 10 mm/min.

The breaking load is determined as an arithmetic mean of five successive maximum values.

2.3.2.4 The strength of interlayer bonds in a textile is determined on rectangular test specimens measuring (50,0 ± 0,5)×(200,0 ± 0,5) mm.

The specimen coat is carefully cut to the cloth and separated using a knife over a length of 50 mm on the side of the oblique notch as shown in Fig. 2.3.2.4 (the separated area is lined). The ends of layers separated in this manner are clamped in the grips of testing machine.

Delamination is effected on a length of 100 mm, and the forces applied are plotted on a graph. The moving rate of the grips is 100 ± mm/min.

The interlayer bond strength is determined as an arithmetic mean of 50 % of the lowest peak values to be found in the graph as measured on the central section of the specimen length making up 50 % of the total separated length.

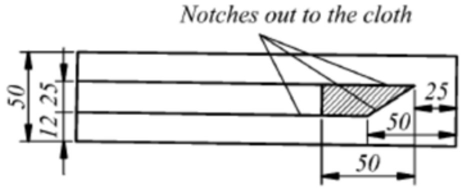


Fig. 2.3.2.4

2.3.2.5 The tear propagation strength of bond joints of laminated textiles is determined on test specimens prepared in such a manner that the middle of the bond joint coincides with the middle of the specimen length and the joint overlaps the specimen by 25 mm.

The shape and dimensions of test specimens are determined proceeding from **2.3.2.2**. The adhesive applied shall agree with the conditions of the products manufacture.

2.3.2.6 The tear propagation strength of retro-reflective materials is determined on specimens 25±1 mm wide having the initial length between the grips of testing machine 100±5 mm.

The moving rate of the testing machine grips is 300±20 mm/min.

Materials with an adhesive layer are tested after removal of protective paper.

2.3.2.7 The strength of the adhesive bondage between the retro-reflective material and the adhesive layer is determined on specimens 25±1 mm wide and 200±5 mm long.

Before testing, protective paper is removed from the adhesive layer of the material on a length of 80+5 mm and placed on the surface being tested which measures (50±5)x(90±5) mm. The loose end of the specimen is secured in the dead lock of the testing machine. Separation of the specimen is achieved by turning the panel by 180° round the axis passing through the specimen end opposite to the loose one.

2.3.3 Compression test.

2.3.3.1 Compression strength of glass-reinforced plastics shall be determined on the test specimens according to Fig. 2.3.2.1-1 and Table 2.3.3.1.

Table 2.3.3.1

L_1, L_2, mm	L_3, mm	b_1, mm	b_2, mm	r, mm	t, mm
Not regulated	80	20	10 ± 0,5	160	10

2.3.3.2 Compression strength of rigid foamed plastics shall be determined on rectangular test specimens with side dimensions (50,0±0,5)x(50±0,5) mm and a height from (25±1) to (50±1) mm.

The load is increased uniformly. The stress rate shall not be in excess of 5 mm/min.

2.3.4 Determination of modulus of elasticity for glass-reinforced plastics.

The modulus of elasticity in tension shall be determined according to **2.3.2.1**, and in compression according to **2.3.3.1**.

The strain increment is determined with initial load P_0 and maximum load P_{max}, which are equal to 2 and 8 - 10 % of the breaking load, respectively.

2.3.5 Bend test.

2.3.5.1 The bend test of rigid foamed plastics shall be carried out on the test specimens, the length of which is

(120±1,2) mm, width (25±0,25) mm and thickness (20±0,2) mm.

The distance between the supports shall be 100 mm, rounding of the supports and the punch (5±0,2) mm. The rate of punch feed is (10±2) mm/min.

2.3.5.2 The bend test of glass-reinforced plastics shall be carried out on test specimens, the length of which equals 20 times their thickness and the breadth is 25 mm. The distance between the supports shall equal 16 times the specimen thickness. The load applied to the midlength of the specimen shall be smoothly increased until the latter breaks.

2.3.5.3 Bend test of laminated textiles.

The test is effected on rectangular specimens measuring (300±5)x(50±1) mm, which are fixed in the testing arrangement as shown in Fig. 2.3.5.3.

When the test specimen is fixed the distance between the grips shall be 30 mm. The test specimen being fixed, the grips are brought together until they touch each other.

At this time, the load upon the test specimen shall be 10 N.

During the test, the movable grip makes 500 cycles of reciprocating movement with a frequency of 2 Hz and an amplitude of 50 mm.

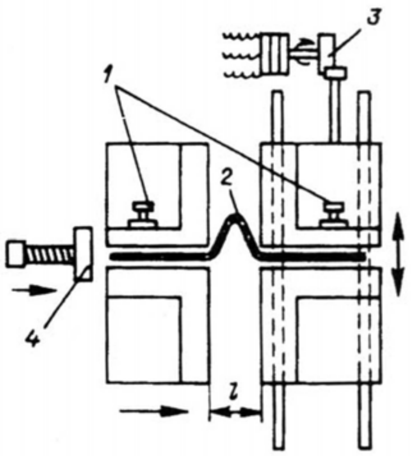


Fig. 2.3.5.3: 1 –grip; 2 –test specimen; 3–motor; 4 – load

2.3.6 Determination of relative glass content in glass-reinforced plastic by mass.

In the furnace at a temperature of (625 + 25)°C resin is removed from a specimen having dimensions (10±1,0)x(10±1,0) mm6laminate thickness, the mass of which together with a crucible shall be determined with an accuracy up to 0,01 g.

The glass content in the mass, in %, is obtained from the following formula:

$S = (G_2 - G_0)\cdot 100/(G_1 - G_0)$,

where G_1 and G_2 – mass of the crucible together with the specimen before and after roasting, g;

G_0 – mass of the empty roasted crucible, g.

2.3.7 Determination of apparent density of foam plastics.

The apparent density of foam plastics shall be determined on test specimens of regular shape, having a volume not less than 100 cm3 .

Before conditioning in accordance with **2.3.1.1** the test specimens shall be dried at a temperature 40 ± 5°C.

The apparent density is determined as the ratio of the mass of the specimen to its volume, in m^3.

2.3.8 Determination of shrinkage of plastics at limiting temperature.

A test specimen with dimensions (100 ± 1) × (100 ± 1) × (15 ± 0,5) mm is conditioned at the appropriate temperature during 48 h.

Shrinkage is determined as the ratio, in %, of linear deformation to the appropriate original size of the specimen.

2.3.9 Water absorption test.

2.3.9.1 Water absorption shall be determined on test specimens having the dimensions (50±1)x(50±1) mm and a thickness equal to the thickness of the product, but not more than 50 ± 1mm.

Before testing the specimens shall be dried to constant mass; drying conditions are specified in the relevant standards. After drying and weighing the specimens are immersed into distilled water and kept at a temperature 23 ± 2°C for 24 h. Then they are weighed again. Water shall be removed from the specimen surface.

Water absorption is obtained as a fraction of total mass of absorbed water related to the mass of the dry specimen. Water absorption of foamed plastics is determined as mass of absorbed water related to the surface area of the specimen.

2.3.9.2 A sample, the size of which is determined proceeding from the required number and size of specimens, is immersed in fresh water, the temperature of which is 23±2°C, to a depth of 1,25 m and conditioned for 7 days.

Before testing, as well as a day and seven days after immersion, the sample is weighed. After conditioning, test specimens are prepared from the sample.

2.3.10 Ageing test.

2.3.10.1 A sample, which dimensions are determined depending on the required number and dimensions of test specimens is conditioned in semi-immersed condition in the artificial sea water with a temperature 23±2 °C for 30 days. In the process of conditioning the sample shall be subjected every day to two-hour ultra-violet irradiation with 500 W lamp placed at a distance of 50 cm from it. After conditioning test specimens are prepared from the sample for carrying out the required tests.

2.3.10.2 Two samples, the size of which is determined proceeding from the number and size of specimens required are kept suspended during seven days at ambient temperature 70±1°C, one of the samples being suspended in a closed volume above water. After that, the same number of test specimens is prepared out of each sample.

2.3.10.3 The test for creasing and stability of shape after ageing is effected on square specimens with a side measuring 100+5 mm, which are folded in two directions, parallel to the edges and at right angles to each other, unfolded and then folded once more along the same folds, but in the opposite direction.

After each folding, the edges are smoothed down with the fingers.

2.3.10.4 A sample, which size is determined proceeding from the number and size of specimens required, is subjected to the ultra-violet irradiation by means of a lamp having a power of 500 W from a distance of 50 cm during 30 h for type 1 retro-reflective material and during 60 h for type 2 material.

2.3.11 Petroleum-product resistance test.

2.3.11.1 A disc-shaped specimen with diameter 70 ± 5mm is inserted in the testing arrangement as shown in Fig. 2.3.11.1.

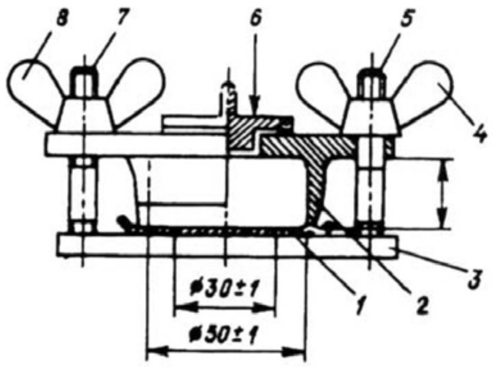


Fig. 2.3.11: 1 - test specimen; 2 - cylindrical chamber; 3 - base plate with a hole of 30 mm diameter; 4, 8 - wing nuts; 5, 7 - bolts; 6 - plug.

The arrangement is filled up to the level of 20 mm with a mixture of oils in the following proportion:

30 % of 2, 2, 4 - trimethylethane;

50 % of toluene;

15 % of diisobutylene;

5 % of ethanol.

Other oil products may be used such as diesel fuel, petrol, etc.

The test specimen is conditioned in oils during 22 h at a temperature 20 ± 2°C.

When the test specimen is extracted, it shall be dried a little bit, the wet surface folded in two and the halves pressed to each other. The wet surfaces shall not stick to each other, nor shall the fingers be stained when the surfaces shalluched.

2.3.11.2 A sample, which size is determined proceeding from the number and size of specimens required, is immersed in diesel oil having a temperature of 23 ± 2°C and conditioned there for 30 days. After conditioning, test specimens are prepared from the sample.

2.3.11.3 A sample, which size is determined proceeding from the number and size of specimens required, is immersed in diesel oil or high octane petrol having a temperature of 23 ± 2°C to a depth of 100 mm and conditioned there during 24 h.

2.3.11.4 Samples, which size is determined proceeding from the number and size of specimens required, are immersed in crude oil, fuel oil, diesel fuel, high octane petrol and kerosene having a temperature of 23 ± 2°C to a depth of 100 mm and conditioned there for 14 days. After conditioning, test specimens are prepared from the samples.

2.3.12 Water resistance test.

2.3.12.1 A sample, which dimensions are determined depending on the required number and size of test specimens, is immersed in artificial sea water with a temperature of 23 ± 2°C and conditioned during 5 months.

After conditioning, test specimens are prepared from the sample.

2.3.12.2 In the case of laminated textiles, a sample measuring 300x200 mm glued along the perimeter shall be conditioned in salty water with salt concentration 3,3 - 3,8 % during 4 h at a temperature of 40±1°C and at a depth of 500 mm.

2.3.12.3 Specimens of retro-reflective material measuring (70 ± 5) × (150 ± 5) mm, which are secured on an aluminium panel and have an X-shaped diagonal cut in them, are conditioned in artificial sea water at a temperature of 23 ± 2°C in semisubmersed condition during 16 h in enclosed volume.

After conditioning, the salt residues on the specimen surface shall be washed off.

2.3.12.4 Specimens of retro-reflective material measuring (70 ± 5) × (150 ± 5) mm, which are secured on an aluminium panel, are sprayed with 5 % salt solution and conditioned at a temperature of 35± 2°C for 5 days.

During conditioning, the specimens are dried for 2 h every 22 h.

2.3.12.5 Specimens of retro-reflective material manufactured and mounted in conformity with **2.3.2.7** are soaked in distilled and artificial sea water during 16 h in enclosed volume.

2.3.13 Air permeability test.

A disc-shaped specimen having a diameter of 350 mm is covered with wax in such a way that its centre, 290 mm in diameter, is left open, and then clamped between the flanges of the testing apparatus as shown in Fig. 2.3.13.

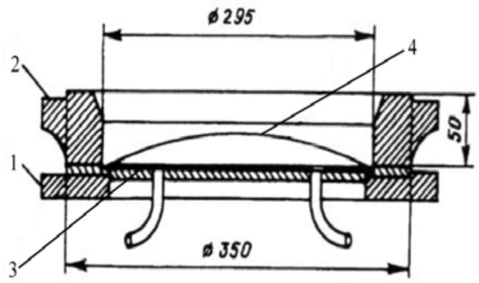


Fig. 2.3.13: 1 - base plate; 2 - clamping ring; 3 - specimen; 4 – specimen surface during test.

From below, a positive air pressure of 27,5 kPa acts upon the test specimen. In 10 to 15 min, the specimen is so immersed in water that its uppermost point is 13 mm below the surface. 1 min later no air bubbles shall remain on the specimen surface.

Within the following 5 min no bubbles shall rise to the surface.

2.3.14 Cold resistance test.

The cold resistance test of laminated textiles is effected on rectangular specimens measuring (100 ± 5) × (50 ± 5) mm.

After being conditioned at a temperature of -30... -5°C during 1 h and at -80... -5°C during 10 min, the specimens are bent through an angle of 90°C. A sketch of testing apparatus is shown in Fig. 2.3.14.

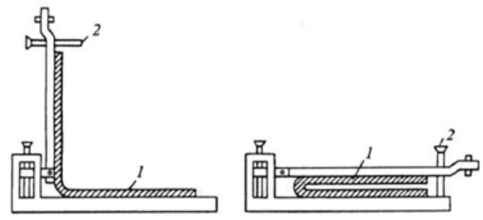


Fig. 2.3.14. Sketch of testing machine: 1 – specimen; 2 – regulating screw

By the end of the test the distance between the parallel parts of the test specimen shall equal four times its thickness.

2.3.15 Ozone resistance test.

A test specimen is bent through 180° round a mandrel equalling six times the specimen thickness in diameter and subjected during 1h to the influence of air with ozone concentration of 50 pphm at a temperature of 30±2°C and the relative humidity of 26 %.

2.3.16 A sample, the size of which is determined proceeding from the number and size of specimens required, is successively exposed to ambient air at a temperature of -40 and +70°C at 8 hour intervals for foam plastics and at 24 h intervals for retro-reflective materials.

2.3.17 Vibration load test.

A test specimen, the type and size of which are determined proceeding from the expected service of the product, is mounted on a vibration-testing machine and subjected to vibration loads having the following parameters:

oscillation amplitude - 2,5 mm;

frequency range - 5 to 500 Hz with a difference of frequency of 32 Hz and an amplitude of vibration acceleration of 10 *g*.

2.3.18 Determining the retro-reflection factor of a material.

2.3.18.1 The retro-reflection factor is determined on square specimens measuring 150 ± 5 mm. The entrance and observation angles are adopted in accordance with Table 6.7.2.2.

Measurements are taken at the turning angles of reference plane between 0 and 180° with the spacing not exceeding 30°.

2.3.18.2 The retro-reflection factor for a material staying under a film of water is determined on specimens measuring (150 ± 5) × (75 ± 5) mm secured on a vertical plane in the transverse direction.

During testing, the specimen stays under a continuously moving film of water. A sketch of the testing machine shall be found in Fig. 2.3.18.2.

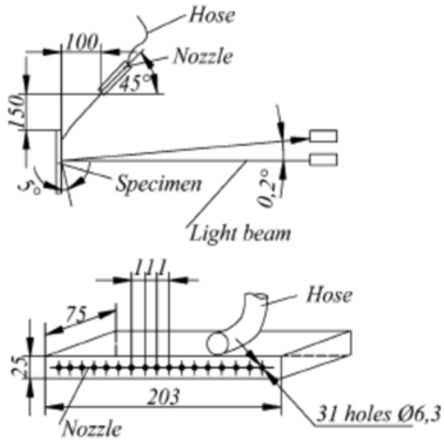


Fig. 2.3.18.2

Measurements are taken at the observation angle of 0,2° and entrance angle of 5°.

2.3.19 The bend test of retro-reflective materials is made on specimens measuring (25 ± 5) × (150 ± 5) mm after they have been conditioned, together with a metallic mandrel 3,2 mm in diameter, in a heating chamber at a temperature of 30°C. The specimens shall be wrapped on the mandrel by a slight touch of the finger.

Retro-reflective materials with an adhesive layer are tested after the removal of protective paper.

2.3.20 The adhesion test of retro-reflective materials is made on square specimens measuring 100 ± 5 mm.

Two specimens are fitted between glass plates 3 mm thick, with their retro-reflective surfaces facing each other and under a load, the mass of which is 18 kg, and conditioned in the heating chamber at a temperature of 65 ± 2°C during 8 h.

After being conditioned, the specimens are cooled at a temperature 23 ± 2°C during 5 min.

2.3.21 Retro-reflective materials are tested for fungus resistance using square specimens measuring 75±2 mm, which are secured on an aluminium panel.

The specimens are conditioned in the soil during two weeks. After being conditioned, the specimens are wiped clean with a soft cloth wetted in the 70 % solution of ethanol alcohol and then conditioned in accordance with **2.3.1.1** during 48 h.

The microbiological activity of the soil is determined on untreated cotton cloth.

After being soilconditioned for 5 days, the ultimate strength of the cloth with a density of 400 to 475 g/m^2 shall not be less than 50 % of the initial value.

2.3.22 The abrasion-resistance test of retro-reflective material is made on specimens measuring (150 ± 5) × (425 ± 5) mm, which are secured on an aluminium panel.

The panel, which is fixed in the testing machine, is subjected to 1000 cycles of the reciprocating action of bristles at a frequency of 37 ± 2 cycles per minute.

For testing, trimmed black bristles of a pig are used arranged in clusters in 60 openings 4 mm in diameter on a block measuring (90 ± 5) × (40 ± 5) ×(12,5 ± 5) mm and having a total weight of 450 ± 15 g. The bristles shall project above the block surface by not more than 20 mm.

2.3.23 The contaminant-resistance test of retro-reflective material is made on square specimens measuring 150 ± 5 mm, which are secured on an aluminium panel.

The specimens are covered with a contaminant layer 0,75 mm thick, a laboratory glass is placed above, and so they remain for 24 h.

After conditioning, the specimens are wiped clean of the contaminant with a soft cloth wetted in white spirit, washed with 1 % solution of a detergent and rinsed in water.

The contaminant used for testing shall have the following composition by weight: 8 parts of soot, 60 parts of mineral oil and 32 parts of white spirit.

2.4 WELDABILITY TEST

2.4.1 The Chapter contains general requirements for the weldability testing procedure of materials being approved.

The number of tests is determined by the test program approved by the Register.

Among the products tested for weldability there are rolled steel, steel castings, steel forgings and aluminium alloys applied in welded ship structures.

The test is carried out under the supervision of the Register or in a laboratory recognized by that body.

2.4.2 The weldability of a material shall be examined in the course of approval tests by using the same welding methods that would be applied when producing structures subject to survey by the Register. The welding methods are indicated in the approval documentation for the material.

2.4.3 During the weldability test the following shall be determined:

.1 chemical composition and mechanical properties of the base metal;

.2 cold cracking resistance;

.3 susceptibility to ageing according to **2.2.3.4**;

.4 welded joint properties according to Section **4**, Part XIV "Welding".

2.4.4 The tests mentioned under **2.4.3** shall be made on plates or other products of maximum thickness taken from at least three different casts.

2.4.5 For metallic materials other than steel the weldability in each particular case is determined proceeding from the results of tests made in conformity with the Register approved program or according to the standards approved by the Register.

2.5 TESTING OF ICE-RESISTANT COATINGS

2.5.1 Assessment of anticorrosive properties in sea water.

2.5.1.1 Tests shall be carried out in compliance with ДСТУ ISO 12944-6 or the relevant ISO standard for a corrosivity category Im2 in compliance with ДСТУ ISO 12944-2 or the relevant ISO standard. The duration of testing shall be set for the coating lifetime of 15 years.

2.5.1.2 Preparation of test specimens.

Panels for testing shall be made of the steel of the grade used in practice.

The panel shall be dimensioned 150x70 mm as a minimum.

The panel thickness shall be least 2 mm, depending on the test. The panel surface shall be worked by abrasive blasting to standard Sa $2^1/_2$ or Sa 3 as per ДСТУ ISO 8501-1 or the relevant ISO standard. The surface roughness (profile) shall correspond to an average value (G) as per ISO 8503-1 and can be checked using a standard as per ДСТУ ISO 8503-2 or the relevant ISO standards.

Three panels shall be prepared for each type of tests.

Paint shall be applied according to the manufacturer's instructions. It is recommended to apply paint on the panel by airless spraying method. Each layer shall be uniform in thickness and look homogeneous, have no runs, sags, holidays, gas bubbles, wrinkles, blushing changes, paint lack, hard particle inclusions, dried top skin and blisters. The thickness of a dry film as per ДСТУ ISO 2808 or the relevant ISO standard shall not exceed the nominal value by more than 20%.

Prior to testing, the painted test panels shall be conditioned during three weeks at normal temperature (23±2)°C and a relative humidity (50±5)% or at temperature (20±2)°C and a relative humidity (65±5) %.

The panel edges and back side shall be properly protected. In order to confirm a large lifetime in sea water, the tests shall be carried out according to the following:

ISO 9227 (neutral salt spray) during 1440 h;

ISO 2812-2 (immersion in water) during 3000 h.

2.5.1.3 Assessment of the coating system before artificial ageing in the salt spray and when immersed in water. Prior to testing, the adhesion assessed by the cross-cut method as per ДСТУ ISO 2409 or the relevant ISO standard shall be classed 0 or 1.

For the coating system over 250μм, m thick, the test as per ДСТУ ISO 4624 or the relevant ISO standard shall be carried out instead of the test as per ДСТУ ISO 2409 or the relevant ISO standard.

The coating is considered to have passed the test if the substrate (A/B) adhesion is retained intact at a pull-off force of less than 5 MPa.

2.5.1.4 Salt spray tests.

The specimens to be tested in a salt spray chamber shall be notched to a substrate with length of 50 mm and at a distance of at least 20 mm from the test specimen edge.

The method principle consists in conditioning the painted specimens in the salt spray chamber with the following assessment of the extent of the paint coating destruction.

The test specimens shall be placed in the chamber facing upwards at an angle of (25±5)° to the vertical.

The specimens shall be placed in such a way as to avoid the contact with each other or the chamber, and the solution shall be freely sprayed on the surface exposed.

The specimens shall be placed at the same level, so that the solution drops may not drain off the plates or their supports onto the other specimens placed below.

The temperature inside the chamber shall be within (35±2)°C.

In every 24 h, as a minimum, the average rate of solution accumulation in each collector for a horizontal collecting area of 80 cm^2 (a funnel of 100 mm in diameter) shall be measured and be equal to 1 – 2,5 ml/h. The sodium chloride concentration in each collector shall be (50±10) g/l, pH = 6,5 – 7,2.

The specimens shall be periodically visually examined as per Parts 2 – 5, ДСТУ ISO 4628 or the relevant ISO standard, leaving therewith the surfaces under test undamaged. The examination time shall not exceed 30 min.

The examinations shall be performed once in 24 h at the most and at the same time of a day. The specimens shall not fully dry out during the examination and, following the latter, shall be immediately returned into the test chambe.

2.5.1.5 Water immersion test as per ISO 2812-2.

The tests shall be carried out in a properly dimensioned tank (recommended dimensions are 700x400x400 mm). The tank shall have closing appliances, be heat-resistant and be provided with a water solution circulation and aeration system. The solution concentration shall be maintained at the level of 50 g of NaCl per 1 dm^3 of water.

The temperature of water in the tank shall be (40±1)°C.

The specimens shall be immersed in the tank to 3/4 of their length at a distance of 30 mm from one another, the tank sides and bottom. The specimen holders shall be positioned so that the specimens are inclined at an angle of (15 – 20)° to the vertical, and the surface under study shall therewith be at the top and parallel to the direction of a water flow in the tank.

The specimen positions shall be periodically interchanged.

The intermediate examinations of specimens shall be carried out in 1, 3 and 5 weeks and every 250 h of the test.

During the intermediate examinations each specimen shall be taken out of the tank, blotted with a filter paper and the extent of its coating destruction shall be assessed as per Parts 2 – 5, ДСТУ ISO 4628 or the relevant ISO standard during 1 min. Following that, the specimen shall be immediately returned into the tank.

2.5.1.6 Assessment after artificial ageing test during the set time.

After the artificial ageing test in compliance with ISO 9227, any substrate corrosion due to a scratch shall not exceed 8 mm if determined by Formula (2.5.1.6.2).

Any defects within 1 cm from the panel edges shall be ignored.

Table 2.5.1.6 **Requirements for coating condition after artificial ageing test during the set time**

№	Assessment method	Requirements
1	ДСТУ ISO 4628-2 or the relevant ISO standard	Blistering 0(S0) (assessed without delay)
2	ДСТУ ISO 4628-3 or the relevant ISO standard	Rusting Ri0 (assessed without delay)
3	ДСТУ ISO 4628-4 or the relevant ISO standard	Cracking 0(S0) (assessed without delay)
4	ДСТУ ISO 4628-5 or the relevant ISO standard	Flaking 0(S0) (assessed without delay)

2.5.1.6.1 Нанесення подряпини.

An engraving machine is recommended for use to get reproducible results. Where it is impracticable, the device for scratching shall correspond to the description in 4.1.1, ДСТУ ISO 2409 or the relevant ISO standard (a single-bladed cutting tool).

The scratch may be horizontal, vertical or diagonal. It shall be at least 50 mm long, besides it shall be at least 20 mm away from each edge and shall extend to the very surface of the metal at any point of its length.

2.5.1.6.2 Assessment of corrosion lengthwise of scratch.

After salt spray test, the maximum width *C*, in mm, of corrosion across the scratch shall be measured. The substrate corrosion *M* caused by the scratch is determined by the formula:

$$M = (C - W)/2, \qquad (2.5.1.6.2)$$

where *W* - initial width of the scratch, in mm.

2.5.1.7 Other assessment methods. Requirements. The adhesion assessed (in 24 h after conditioning) by the cross-cut test method as per ДСТУ ISO 2409 or the relevant ISO standard shall be classed 0 or 1).

Where the thickness of the dry film of a paint system is over 250 μм the pull-off test for adhesion as per ДСТУ ISO 4624 or the relevant ДСТУ ISO standard instead of using the cross-cut test method as per ISO 2409 or the relevant ISO standard shall be carried out.

No defects are allowed for adhesion with the substrate (A/B) at a pull-off force of less than 5 MPa (assessment shall be performed after 24 h of conditioning).

2.5.2 Assessment of resistance to low temperature.

2.5.2.1 Preparation of test specimens.

Panels for tests shall be made of the steel of the grade used in practice.

The recommended specimen dimensions: 150 x 70 mm or 150 x 100 mm.

The thickness of unpainted plate shall be at least 2 mm.

The panel surface shall be worked by abrasive blasting to standard Sa 21 /2 or Sa 3 as per ДСТУ ISO 8501-1 or the relevant ISO standard.

The surface roughness (profile) shall correspond to the average value (G) as per ДСТУ ISO 8503-1 or the relevant ISO standard and can be checked using a standard as per ДСТУ ISO 8503-2 or the relevant ISO standard.

Four panels shall be prepared: 3 panels for testing and 1 check panel. It is recommend to apply paint to the panel by airless spraying method.

Each layer shall be uniform in thickness and look homogeneous. The thickness of a dry film as per ДСТУ ISO 2808 or the relevant ISO standard shall not exceed the nominal value by more than 20 % (refer to **2.5.1.2**).

Prior to test the painted test panels shall be conditioned during three weeks at a normal temperature (23±2)°C and a relative humidity (50+ 5)% or at temperature (20±2)°C and a relative humidity (65±5)%.

2.5.2.2 Test procedure.

Specimens shall be placed in a freezing chamber and conditioned at a temperature – (60+3)°C during 2 h followed by the adhesion assessment within 20 – 25 s using the cross-cut test method as per ДСТУ ISO 2409 or the relevant ISO standard.

Where the thickness of the dry film of a coating system exceeds 250 μm, the cross-cut test method as per ДСТУ ISO 16276-2 or the relevant ISO standard shall be used.

2.5.2.3 Assessment of test results.

Coatings are considered to have passed the tests if adhesion on two of three specimens is classed below 3 as per ДСТУ ISO 2409 or the relevant ISO standard and ISO 16276-2.

2.5.3. Determination of adhesion strength.

The adhesion strength is determined using the pull-off test as per ДСТУ ISO 4624 or the relevant ISO standard. The test provides for measuring the force required to break the coating bond.

2.5.3.1 Preparation of test specimens.

The coating system to be tested is applied to the metal specimens of the same thickness (at least 3 mm) and surface texture.

The surface preparation and coating application shall be carried out in accordance with a process instruction for the coating system to be tested.

Prior to test the painted specimens shall be conditioned at a normal temperature (23±2)°C and a relative humidity (50±5)% during at least 16 h.

2.5.3.2 Preparation for tests.

After specimens drying and conditioning, dollies shall be bonded thereon.

When selecting an adhesive, its unmixed components shall not cause the visible coating changes within the time of the adhesive curing.

Adhesives, which give the highest results, are preferred. In most cases, cyanoacrylate, two-component solventless epoxide and peroxide-catalyzed polyester adhesives shall be used.

The adhesives shall be prepared and applied according to the manufacturer's instructions. To secure a tight, continuous and uniform bond between the dolly and coating, the minimal amount of adhesive shall be applied.

After the adhesive curing (generally 24 h), the adhesive and paint shall be cut about the dolly circumference penetrating through to the metal plate surface.

To reduce the deformation of the painted specimen during pulling off, a rigid metal ring shall be placed around the dolly.

2.5.3.3 Test procedure.

During the test a tensile force shall be uniform across the entire tension area and be applied normally to the painted surface without any bending moment.

The tension stress rate shall not exceed 1 MPa/s and be perpendicular to the painted coating.

The test specimen shall fail within 90 s since tensioning.

To assess the adhesion strength, at least six determinations shall be carried out at a temperature (23 ±2)°C and a relative humidity (50±5)%.

2.5.3.4 Assessment of test results.

After six tests, the mean value of the adhesion strength shall be determined. The result shall be presented as the mean value and the range. The assessment of the mean percentage of the fracture area and the fracture type in the system being tested shall also be provided.

The fracture nature is presented as follows:

A/B - adhesive failure between substrate and the first coating layer;

B - cohesive failure of first coating layer;

B/C - adhesive failure between the first and the second coating layers;

n - – cohesive failure of the *n*-th layer of a multilayer coating system;

n/m - adhesive failure between the *n*-th layer and the *m*-th layer of a multilayer coating system;

-/Y - adhesive failure between the final layer and adhesive;

Y - cohesive failure of adhesive;

Y/Z - adhesive failure between adhesive and dolly.

The area of fracture shall be estimated as a percentage to the nearest 10 % for each type of fracture.

Where the failure is mainly associated with the adhesive, the test shall be repeated using another adhesive or, in order to reduce roughness, the surfaces of the coating and the test dolly may be abraded.

2.5.4 Determination of abrasion resistance.

The method concept is determination of abrasion resistance of the coatings applied on a metal substrate with the Taber's abrader.

2.5.4.1 Preparation of test specimens.

Metal specimens dimensioned 100x100x3 (± 0,5) mm with a hole 8 mm in diameter at the specimen center shall be prepared for testing.

The specimen surface preparation and coating application shall be carried out in accordance with the requirements of a process instruction for the coating system being tested.

If the coating is applied at a temperature (20 – 30)°C, abradability shall be determined at the earliest in three weeks after applying the last coating layer.

2.5.4.2 Test procedure.

The abrasive wheel CS-17 at a 1000 g loading shall be used in testing.

Coated specimens shall be weighed to an accuracy 0,1 mg, and the coating thickness shall be measured at some points within the area to be tested for abrasion.

The coated specimen is placed and secured on a rotating platform. The abrasive wheels are lowered onto the specimen.

The nozzle of a vacuum pump is positioned at a distance of 1 mm above the abrasive disc. A counter is set to zero, and a suction level, to "50". Where the more efficient removal of abrasive dust is needed, the suction level may be increased up to "90". The number of cycles is set to "1000": one cycle of abrasion corresponds to one revolution of the rotating platform.

The vacuum pump and rotating platform are started.

One more specimen, as a minimum, shall be tested.

After testing, the specimen is dismantled, the remains of abrasive dust are removed and the specimen shall thereafter be weighed with to an accuracy 0,1 mg.

2.5.5 Determination of impact resistance in falling-weight testing.

Tests shall be carried out in compliance with ДСТУ ISO 6272-1 or the relevant ISO standard with a 20-mm-diameter spherical indenter, dropped under standard conditions.

The method concept is evaluation of resistance of a dry film of paint coating to cracking or peeling from a substrate when it is subjected to a deformation caused by a falling weight.

The tests shall be carried out using the special apparatus, which meets the requirements in ДСТУ ISO 6272-1 or the relevant ISO standard.

2.5.5.1 Preparation of test specimens.

Test panels shall be flat, undamaged and made of steel names 08kp as per GOST 9045 (ISO 3573) or steel names 08kp, 08ps as per GOST 16523 (or their equivalents), 0,8 - 0,9 mm thick. The panel dimensions shall be such (70x220 mm), as to allow the test to be carried out at least at five positions spaced no less than 40 mm apart and at a distance of no less than 20 mm from the panel edge.

Each panel shall be prepared in accordance with ДСТУ ISO 1514 or the relevant ISO standard by cleaning it with a solvent (xylene, toluene or P-4) and wiping with a filter paper. The cleaning is considered satisfactory if no stains are visible on the paper.

Material of the coating system is applied on the prepared panels. The layer thickness shall be 250 - 300 mm and the time of coating drying shall comply with a specification.

After drying, the coating thickness shall be measured as per ДСТУ ISO 2808 or the relevant ISO standard. The measurements shall be made at, or as near as possible to, the positions where the test shall be carried out.

Immediately before the testing, the panel shall be conditioned at a temperature (23±2)°C and a relative air humidity (50±5)% during at least 16 h.

2.5.5.2 Test procedure.

The tests shall be carried out at a temperature (23±2)°C and a relative air humidity (50±5)%.

It shall be checked that the guide tube is vertical and the secondary weight is attached, if required, to the primary weight in order to achieve the required loading.

The height of the weight to the required release-point (using the graduations on the guide tube) shall be adjusted and the weight shall be locked in position.

The test panel shall be placed on the die with the coated face up, the weight shall be released and allowed to fall on to the test panel.

2.5.5.3 Assessment of test results.

The coating shall be examined with a magnifying glass with 10x magnification. The presence of cracking on the coating of the test panel or peeling from the substrate shall be reported.

The test shall be repeated four times at different positions, giving a total of five drops. The coating is considered satisfactory if at least four test positions show no cracking or peeling from the substrate.

2.5.6 Determination of resistance to cathodic disbondment.

2.5.6.1 Devices and apparatus.

The container of glass or another inert material not affecting the electrolyte pH shall be used for testing.

The container shall be at least 700 mm in diameter or have a side of at least 700 mm, be at least 200 mm high. The container shall be provided with a system for electrolyte aeration.

The anode shall be made of graphite and be, as a minimum, 200 mm long or in diameter, or be made of platinum wire, or platinum grid, or platinized titanium, or other material, which demonstrates the sufficient resistance to anodic polarization in sea water.

Calomel or chlorine-silver reference electrodes shall be used.

A voltmeter with the minimum resistance of 10 MOhm shall provide the measurements within 0 - 2 V to an accuracy 1 mV.

A cathode protective circuit supplied from a d.c. source and being able to maintain an electrode potential of –1050±5 mV on a test specimen with respect to a saturated calomel reference electrode shall be used. It is preferable to use potentiostatic control, but a galvanostat is also acceptable.

Representative cathode circuits are shown in Figs. 2.5.6.1-1 and 2.5.6.1-2.

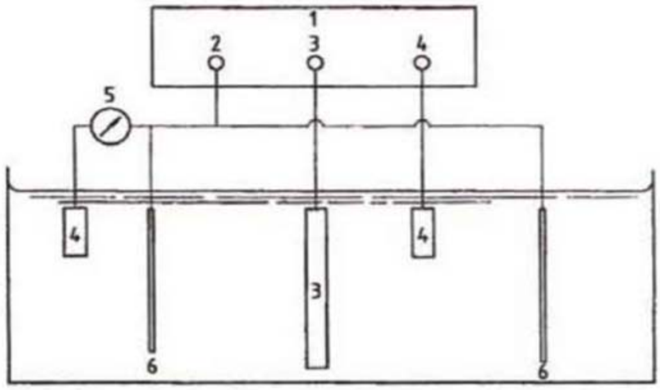


Fig. 2.5.6.1-1 Cathode protective circuit with potentiostatic control:
1 - potentiostat; *2* - work electrode; *3* - anode; *4* – reference electrode; *5* - voltmeter; *6* - test specimen

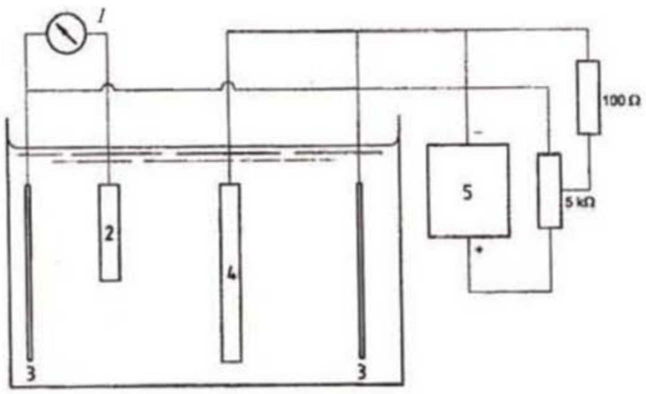


Fig. 2.5.6.1-2 Cathode protective circuit with galvanostatic control:
1 - voltmeter; *2* - reference electrode; *3* - test specimen; *4* - anode; *5* - DC source

2.5.6.2 Preparation of test specimens.

Panels for testing shall be made of the steel of the grade used in practice and dimensioned: 150x70x2 mm.

Each panel shall have an insulated conductor with a reliable electrical contact not subjected to corrosion.

The panel surfaces shall be prepared according to the specification for a coating system.

If the requirements are not specified, the panels shall be worked by abrasive blasting according to ДСТУ ISO 1514 or the relevant ISO standard. Thereupon the panels shall be painted as per the specification for the coating system. It is recommended to apply the same coating system on the panel back side and edges. To prevent edge effect, a thicker film shall be applied on the edges.

All the unpainted surfaces of test specimens and the connections of insulated conductors shall be protected with a coating or paraffin melted at a temperature 70°C, or solvent-free epoxy resin, or another suitable coating with the better protective properties than the material under test.

Three check panels, which will not be connected to the cathode controlled system, shall also be prepared. The thickness of test specimens shall be measured according to ДСТУ ISO 2808 or the relevant ISO standard.

Prior to the commencement of testing, a hole (10±1) mm in diameter shall be made in the coating of each test specimen at a distance of more than 30 mm from the panel edge in any suitable manner but preferably by means of an abrasive jet.

Then the test panels shall be checked for the presence of random pores at a voltage of 10 kV using a continuity detector.

Three panels shall be used in cathode disbondment testing.

2.5.6.3 Test preparation. The anode shall be placed at the center of a tank and connected to the positive pole of the cathode protective circuit.

Each panel shall be numbered by a suitable material, which will remain intact in testing.

Each panel in the tank shall be placed away from the anode and the tank bottom by more than 300 mm and 50 mm, respectively, and completely immersed in electrolyte after filling the tank. The electrolyte composition is given in Table 2.5.6.3. Make sure that the panels do not touch one another and the tank sides, that the side of the panel with a holed coating is not screened from the anode with anything including other panels, and also that nothing interferes with the electrolyte flow around, and between, the panels.

Each panel with a negative pole shall be connected to the cathode protective circuit with an insulated conductor.

The check panels shall be similarly placed in an equivalent tank having no anode and cathode protective circuit.

The tank shall be filled with electrolyte for 200 mm minimum. Electrolyte temperature (23±2)°C shall be maintained.

Table 2.5.6.3 **Electrolyte composition (artificial sea water)**

Component	Concentration, g/l
Sodium chloride	23
Hexahydrated magnesium chloride	9,8
Decahydrated sodium sulphate	8,9
Calcium chloride	1,2

2.5.6.4 Test procedure. The continuous flow of electrolyte in the tank shall be maintained. Electrolyte shall be fully replaced within maximum three days. It is allowed to fully replace electrolyte once in not more than 7 days.

Electrode potential shall be 1050±5 mV relative to the reference electrode. Electrode potential shall be checked once in 24 h or more frequently, if required.

The test duration is 26 weeks. The test duration may be shortened to 3 months in case the confirmation of the positive results of the exploitation of cathode protection coating.

2.5.6.5 Assessment of test results.

The test and check panels shall be subjected to non-destructive testing.

At intermediate examinations, the panels shall be quickly disconnected from the circuit, removed from the tank and washed with the tap water avoiding damages to the coating and removing the cathode sediment at the coating hole. The panels shall remain wet during examinations.

The blisters appeared shall be assessed according to ДСТУ ISO 4628-2 or the relevant ISO standard ,considering the distance from the blisters to the hole.

The results obtained on test and check specimens shall be compared.

After testing, the panels shall be washed in the tap water avoiding damages to the coating.

The coating shall be fully examined and assessed according to ДСТУ ISO 4628-2 or the relevant ISO standard, considering the blisters and hole spacing. The blisters shall be divided into groups: related to the hole and remote from it.

The blisters developed in the areas with the film thickness less than required shall be ignored during the assessment.

The adhesion failure is determined as follows:

two cuts crossing the hole shall be made with a sharp knife on the coating penetrating it to the substrate. The coating around the hole is separated from the substrate with a knife tip;

an approximate distance, in mm, for which the coating may be separated from the substrate as compared with the check specimens, shall be reported.

The results obtained on the test and check specimens shall be compared.

2.5.7 Test for determining coefficient of friction for ice.

2.5.7.1 Preparation of test specimens.

Metal specimens dimensioned (250 x 130 x 3(+0,5)) mm shall be prepared for testing. The specimen surface preparation and coating application shall be carried out in accordance with a process instruction of the coating manufacturer.

2.5.7.2 Description of the device recommended for testing.

Examples of mechanical devices are shown in Fig. 2.5.7.2.

The following symbolic notations are used in Fig. 2.5.7.2: A - specimen; B - bearing plane with recess for ice; C - supporting base; D - force gauge; E - spring gauge, F - constant speed chain drive; G - constant speed tensile tester crosshead; H - constant speed drive rolls; I - nylon monofilament; J - low-friction pulley; K - worm screw; L - half-coupling; M - synchronous motor.

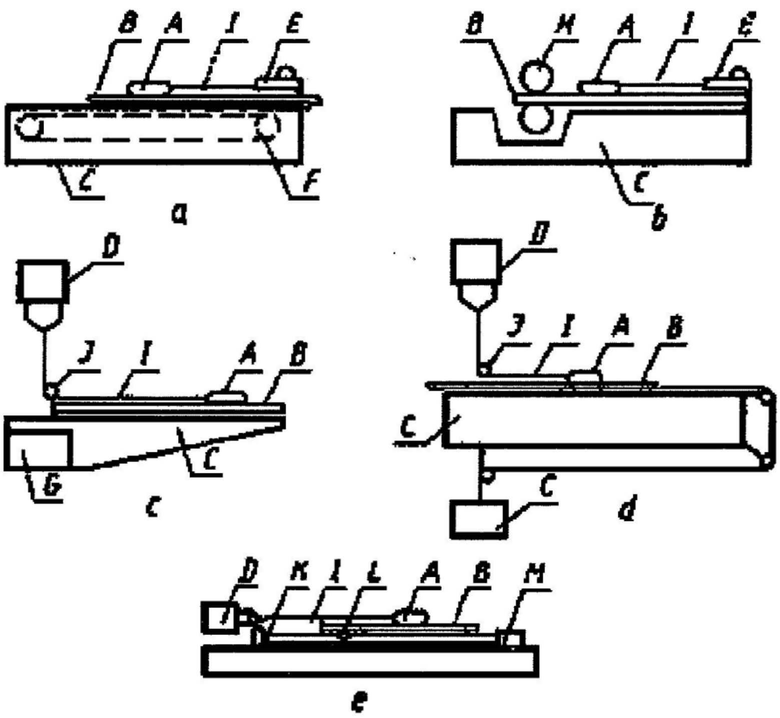


Fig. 2.5.7.2 Devices for determining the coefficient of friction of the protective coating on ice

2.5.7.3 Test procedure.

Panels for tests shall be rectangular dimensioned 250 x 130 x 3(+0,5) мм.

mm. Tests shall be carried out under standard conditions at the temperature of -20^{O}C. For testing purposes, the specimen shall be conditioned at a temperature of -20^{O}C for at least 15 minutes. While performing tests, the bearing plane recess B (see Fig. 2.5.10.2-b) shall be filled with distilled water cooled to minus 2^{O}C.

A panel with applied coating shall be fixed in the device. The tested specimen shall be placed on the bearing plane B of the device. Then the travel mechanism pre-adjusted to a speed of (150±30) mm/min shall be switched on. Due to the frictional loads between the adjoining surfaces of the specimen and ice, they can remain fixed relative to each other until the force shifting the sample becomes equal to or exceeds the static friction force between the surfaces. That maximum initial force value shall be marked as a force, which is a component of the initial (static) coefficient of friction.

The average force value shall be visually marked, as read on the indicator scale with a uniform movement of the surfaces relative to each other at a distance of 130 mm. This force is equal to the kinetic sliding friction force, which is necessary to maintain the surfaces movement relative to each other.

Tests are carried out at least three times.

2.5.7.4 Assessment of the test results. The coefficient of initial (static) friction is calculated as follows:

$\mu S = A_S / m$,

where A_S - initial motion scale reading , in g;

m - specimen weight, in g.

The (kinetic) coefficient of sliding friction is calculated as follows:

$\mu K = AK / m$,

where A_K - average scale reading obtained during uniform sliding of surfaces, in g.

The accuracy algorithm for test results when using the device is approved in accordance with ДСТУ ISO 5725. "Accuracy (correctness and precision) of measurement methods and results" or the relevant ISO standard.

2.6 TESTING OF SHOP PRIMERS NOT REMOVED BEFORE WELDING

2.6.1 General.

The present procedure is applied to approval tests of shop primers not removed before welding, which are intended for protection from corrosion of steel parts during their manufacture, and also covers arc welding. The text of the procedure has been made compliant with the requirements of EN ISO 17652-2 or the relevant ISO standards or EN (DVS 0501, 1976)

The conditions of testing providing the basis for the present procedure imply the presence of a deep root gap in the weld causing high degree of porosity not encountered under normal conditions. However, high degree of porosity is an essential pre-requisite for conducting tests aimed at receiving quantitative estimation of the influence of primers on pore formation during welding. The present test procedure conditions are applicable for specially equipped testing centres.

2.6.2 Test procedure.

2.6.2.1 An overlap weld test specimen is used for testing, as shown in Fig. 2.6.2.1. Plates used for the test specimen shall have the following dimensions: 12 x 80 x 200 mm and 12 x 50 x 200 mm.

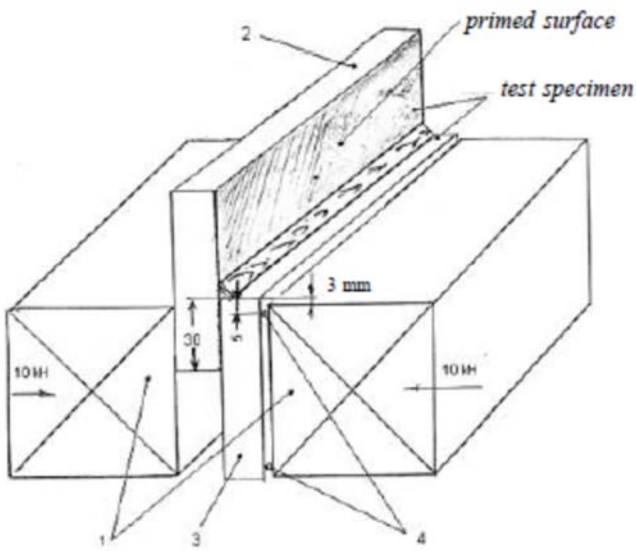


Fig. 2.6.2.1 A standard test specimen for pore formation with a control weld:
1 - vice clamps; 2 - a plate with the dimensions 12 x 80 x 200 mm m coated with controlled shop primer; 3 - a plate with the dimensions 12 x 50 x 200 mm; 4 – 2 mm copper wire; 5 - shop primer; 6 - control overlap weld

To prepare a specimen, in general, low carbon steel shall be used, whose chemical composition complies with the following requirements (% of the mass): C = 0,07 - 0,13; Si ≤ 0,40; Mn = 0,30 - 0,60; P ≤ 0,045; S ≤ 0,045.

Plates shall have smooth, flat and undamaged surfaces. Burrs, if any, shall be carefully removed with a filer along the edge of the overlap joint. Before applying the coating, the parts shall be degreased and cleaned by sand-blasting.

All in all, 8 specimens shall be prepared, each having marking.

2.6.2.2 Only one in two specimens shall be coated, with dry coating skin thickness in accordance with the manufacturer's specifications, as shown in Fig. 2.6.2.1. The coating thickness shall be uniform on the whole surface of the specimen.

The coating thickness shall be measured with the proper devices and with proper accuracy and checked on reference specimens, e.g. smooth plates, at least 1 mm thick or glass plates. In doubtful cases, the coating thickness shall be determined under the microscope.

Plates and specimens shall be coated in one go, that is, one reference specimen as the first and one as the last batch piece.

To determine the mean coating thickness 10 measurements shall be done for each specimen. On the basis of the measurements mean values of the coating thickness and actual deviations are determined. In case of non-compliance with the coating thickness values stated above, the coating shall be removed.

2.6.2.3 Specimens may be welded only after the drying period of the coating in accordance with its specification. Welded plates shall be clamped in a vice along their length with clamping force of 10 kN. In places marked in Fig. 2.6.2.1, a soft-annealed copper wire of 2 mm thickness shall be inserted along the whole length between the plate and the vice jaw. Before welding the clamps shall be tilted to an angle of 45° so that welding can proceed in the lower PA (gravity) position. The following welding parameters shall be observed:

welding process - MAG welding with solid wire electrode: 135 (MAG, ДСТУ ISO 4063 or the relevant ISO standard);

welding procedure - fully mechanized (A);

current - DC electrode positive;

current - 250A, voltage - 30V, welding speed - 300 mm/min;

shielding gas - welding carbon dioxide, type C1 in accordance with EN 439 (purity not less than 99,70%, dew point max- 35^{O}C);

gas flow rate - 15 l/min;

stick out (the distance between the contact tube and the theoretical weld root point)716 mm;

consumable, type - G3Si1 in accordance with EN 440;

consumable, diameter - 1,2 mm.

The chemical composition of the consumable corresponding with the type G3Si1 in accordance with EN 440 (% of the mass):

C = 0,08 - 0,13; Si = 0,80 - 0,95%; Mn = 1,45 - 1,60; P ≤ 0,025;

S ≤ 0,025; Ni ≤ 0,15; Mo ≤ 0,15; Al ≤ 0,02; Ti + Zr ≤ 0,15.

Consumable surface: coppered.

The values of the welding current, voltage, welding speed, gas flow rate and stick out rate shall be contained within ±5% of the nominal limit.

Electrical measuring devices used to control the technological welding process shall have the tolerance class of not more than 1 %.

2.6.3 Determination of porosity.

Welds shall be subjected to breaking in such a manner that pore boundaries are clearly visible. Breaking shall be done alone the bisecting line of the angle made by the edges of the welded joint. If this requirement is not fulfilled, the specimen shall be discarded.

Evaluation shall be done at x10 magnification. The image shall be projected onto a polished glass disc of about 200 mm in diameter, where the area of pores shall be determined. The size of an individual pore shall be determined as the largest in the two mutually perpendicular directions. The pore projection is determined as an ellipse with two sizes as main axes, on the basis of which the pore area is calculated.

Pores, the largest main axes of which are ≤ 0,5 mm, non-magnified, are not evaluated.

Evaluation shall be done on the basis of 100 mm: 60 mm from the beginning of the weld and 40 mm from the end of the specimen are not included in the estimation of the results. The following data shall be determined for each specimen:

the number of pores, n;

the total pore area, F mm^2;

the mean area of an individual pore, mm^2.

Mean values (expected values) and 95 % confidence intervals shall be set for the following parameters:

the number of pores and the total pore area summed;

the area of an individual pore and the 95 % confidence interval for mean values with the accuracy to one decimal place.

2.6.4 Test report.

A test report shall be compiled for each test, containing the following:

primer mark/brand name;

characteristics of the coating pigments;

characteristics of the bonding base of the coating;

chemical composition of the specimens of the base metal and welding wire;

coating thickness (individual and mean values);

calculation results (individual and mean values): number of pores, n; total pore area, mm^2;
mean area of individual pores, mm^2;
conclusion on the compliance/non-compliance with the requirements of **6.5.4.4**;
date, name and address of the testing centre. The signature of the executive in charge and the person responsible for conducting the tests.
The following documents shall be attached to the report:
a report on selection of the specimens from the batch of products indicating the batch number;
Manufacturer's Certificates for the shop primer;
Manufacturer's Certificates for the base metal and welding consumables;
the Manufacturer's Certificate for the shielding gas used during welding tests for pore formation.

3. STEEL AND CAST IRON

3.1 GENERAL

3.1.1 The present requirements are valid for hull structural steel, steel for boilers and pressure vessels, steel pipes and tubes, steel for structures operating at low temperatures, chains, steel forgings and castings, cast iron and steel wire ropes.

In accordance with **1.1.4** all the materials, semi-finished products and items mentioned in this Section shall be manufactured by recognized works (refer to **1.3.1.4**).

A recognition procedure for manufacturers of hull structural steel, which is given in **1.3.5**, is equally applicable to works manufacturing the following goods:

.1 steel for boilers, heat exchangers and pressure vessels (refer to **3.3**);

.2 steel for structures operating at low temperatures (refer to **3.5**);

.3 high strength steel for welded structures (refer to **3.13**);

.4 Z-steel (refer to **3.14**).

At the same time, provisions of a works recognition procedure, stated in 1.3.5, which concern rolling modes, scope of tests, sampling, types and procedures of tests, as well as requirements to test results, shall be specified and agreed in the course of test programs consideration.

3.1.2 It is permitted to use semi-finished products manufactured according to standards or other specifications, if it is proved that requirements contained therein are equivalent to those stipulated by the Rules.

3.1.3 3 Steel shall be melted in an oxygen steel-making converter, electric or open hearth furnaces, and cast iron in cupolas or electric furnaces. The deoxidation of steel is conducted in accordance with the requirements of Tables 3.2.2-1 and 3.2.2-2. The condition of steel supply shall meet the requirements of Tables 3.2.4-1 and 3.2.4-2.

Use of other methods of steel and cast iron making shall be agreed with the Register.

When steel is not produced at the works where it is rolled, forged or drawn, a Manufacturer's Certificate shall be supplied to the surveyor at the mill engaged in further processing of the steel stating the steelworks, process of manufacture, number of cast and chemical composition of steel.

The surveyor shall have access to steel-making and steel-rolling works.

3.1.4 The possibility of application, in particular hull structural members not essential to the longitudinal strength, of materials not fully complying with the requirements of this Section shall be determined by the Register after checking the stated characteristics as ensuring the required level of structures safety. Technical supervision during the acceptance of such materials by the Register shall be performed in accordance with **1.6** of Part **III** "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

3.1.5 The conclusion by the Register on the conformity of hull structural steel grade may be given after performing the tests specified in the relevant Chapters of this Section.

3.2 HULL STRUCTURAL STEEL

3.2.1 Загальні вказівки.

3.2.1.1 The requirements of the Chapter apply to the weldable hot-rolled steel of a normal and higher strength used for plates, strips, sections and bars and intended for hull structures and components being subject to the Register survey during their manufacture.

Hull structural steel conventionally falls into normal strength steel (a minimum yield stress 235 MPa) and higher strength steel (of three strength levels with a minimum yield stress of 315, 355 and 390 MPa, respectively). The requirements for high strength steel (a minimum yield stress 420 MPa and over) are given in **3.13**.

The steel is subdivided into grades as shown in Tables 3.2.2-1 (for normal strength steel), 3.2.2-2, 3.2.3 and 3.5.2.3 (for higher strength steel) depending on the values and conditions required for the performance of impact testing.

The relevant data for high strength steel are given in Table 3.13.3-1. The requirements of normal and higher strength corrosion-resistant steel for cargo oil tanks are specified in 3.18.

The requirements of the Chapter depending on the rolled products thickness apply to the steel of the following types: *steel plates and strips* of all grades having thickness 100 mm and less;

steel sections and bars of all grades having thickness 50 mm or less.

The requirements for steel rolled products of a larger thickness than specified above may be different from the stated ones, but shall be considered in each particular case and agreed with the Register.

Steel that does not fully meet the requirements stated in this Chapter, differs in composition, deoxidation practice and alloying as well as mechanical properties (e.g. intermediate upper yield stress level, as compared to that required in **3.2.3** and other respective characteristics) may be accepted by the Register for use, except for in hull structural elements (Part II).

Such steel shall be given a special designation, the letter S may be added to the grade symbol.

3.2.1.2 The recognition of steel rolled products manufacturers by the Register shall be carried out in accordance with **1.3.5** for each steel grade stated by the manufacturer, for the semi-finished product type and condition of supply.

Where different steel production technologies are used at the works, materials approval is carried out individually for each of them.

The weldability of each steel grade and its suitability for bending shall be confirmed by the manufacturer during the initial recognition of steel rolled products by the Register.

The survey and tests at the manufacturer's during its recognition by the Register are conducted in accordance with the program (chart) agreed with the Register.

3.2.1.3 A manufacturer bears responsibility and assures the use of necessary technological production processes, systems and monitoring methods.

In case of the deviation of production technology or monitoring and/or of the product quality level degradation, the manufacturer shall identify the cause and take all measures to prevent its recurence. The report on the investigations and analysis conducted on the deviations that took place shall be submitted to the representative of the Register. Products with abovementioned deviations may be allowed to use for the intended purpose, if test results are positive. Scope and frequency of tests may be increased until the stability of product test results and the confidence in quality level have been recovered.

3.2.1.4 The rolling procedures for normal and higher strength steels used by a manufacturer shall comply with the condition of supply given in **3.2.4**, and for higher strength Grade F steel with that given in **3.5.2.4**, and for higher strength steel with that given in **3.13.4**.

The applicable rolling procedures are presented in Table 3.2.1.4 in the form of diagrams, and their definitions are given below.

As rolled (AR) means procedure, which involves steel being cooled as it is rolled with no further heat treatment. The rolling and finishing temperatures are typically in the austenite recrystallization region and above the normalizing temperature. The strength and toughness properties of steel produced by this process are generally less than steel heat treated after rolling or than steel produced by advanced processes.

Normalizing (N) means procedure, which involves heating and holding rolled steel above the critical temperature, AC3, and in the lower end of the austenite recrystallization region for a specific period of time, followed by air cooling. The process improves the mechanical properties of as rolled steel by refining the grain size and homogenizing the microstructure.

Controlled rolling (CR) (Normalizing rolling (NR)) means rolling procedure in which the final deformation is carried out in the normalizing temperature range, allowed to cool in air, resulting in a material condition generally equivalent to that obtained by normalizing.

Thermo-mechanical rolling (TM) means a procedure, which involves the strict control of both the steel temperature and the rolling reduction. Generally, a high proportion of the rolling reduction is carried out close to the A_{r3} temperature and may involve the rolling in the dual phase temperature region.

Unlike controlled rolled (normalized rolling), the properties conferred by TM cannot be reproduced by subsequent normalizing or other heat treatment.

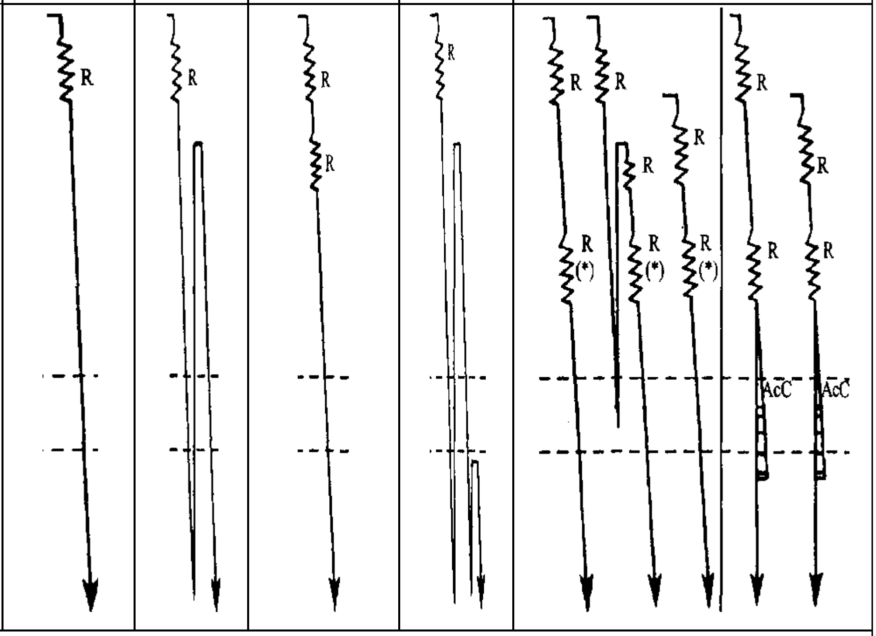
The use of accelerated cooling on completion of TM-rolling as well as the use of tempering after completion of TM-rolling shall be agreed with the Register.

pletion of TM-rolling shall be agreed with the Register. Accelerated cooling (AcC) means a process, which aims to improve mechanical properties by controlled cooling with rates higher than air cooling immediately after the final

TM-rolling operation. Direct quenching is excluded from accelerated cooling. The material properties conferred by TM and AcC cannot be reproduced by subsequent normalizing or other heat treatment.

Quenching and Tempering (QT) : quenching involves a heat treatment process in which steel is heated to an appropriate temperature above the A_{C3}, held for a specific period of time, and then cooled with an appropriate rate for the purpose of hardening the microstructure; tempering subsequent to quenching is a process in which the steel is reheated to an appropriate temperature not higher than the A_{C1}, maintained at that temperature for a specific period of time to restore toughness properties (*KV*) by improving the microstructure and reduce the residual stress caused by the quenching process.

Table 3.2.1.4. **Diagrams of steel processing procedures**

Structure	**Temperature**	**Type of processing**				
		Conventional processes				**Thermo-mechanical processes**
		AR	N	CR(NR)	QT	TM
Recrystallized austenite	Normal slab heating temperature Normalizing or quenching temperature					
Non-recrystallized austenite	A_{r3} or A_{C3}					
Austenite + Ferrite	A_{r1} or A_{C1}					
Austenite + Pearlite or Ferrite + Bainite	Tempering temperature					

Symbols:
R – reduction;
(*) – temperature of the dual phase region of austenite and ferrite;
CR(NR) – (Controlled Rolling (Normalizing Rolling);
TM – (Thermo-Mechanical Rolling (Thermo-Mechanical Controlled Process);
AR – as rolling procedure corresponding hot-rolled steel making (As Rolled);
AcC – (Accelerated Cooling).;
N – (Normalizing);
QT – (Quenching and Tempering);

3.2.1.5 When the works are surveyed, the documentation, which describes and specifies the fulfilment of CR, TM, schedules or TM with AcC, normalising, quenching with tempering, etc., shall be submitted to the Register representative on his demand.

As specified in 3.2.1.3, a manufacturer is responsible for the observance of all mentioned rolling schedules and heat treatment procedures in the process of steel manufacture. The appropriate records shall be verified by the manufacturer and submitted to the Register representative when performing his duties.

Where deviations from the programmed rolling schedules or heat treatment procedures exist, the products may be accepted for use on conditions set forth in **3.2.1.3**.

The attention of the users shall be drawn to the fact that when fatigue loading is present, the effective fatigue strength of a welded joint of higher strength steel may not be greater than that of a welded joint in normal strength steels.

Before subjecting steels produced by thermo-mechanical rolling to further heating for forming or stress relieving, or using high heat-input welding, special consideration shall be given to the possibility of a consequent reduction in mechanical properties.

3.2.2 Chemical composition and structure.

The chemical composition of steel shall be determined by the manufacturer from the results of analysis of the samples taken from each ladle of each cast. The manufacturer's analysis will be accepted subject to periodical checks if required by the Register.

The chemical composition of normal strength steel shall comply with the requirements of Table 3.2.2-1 and that of higher strength steel - with the requirements of Table 3.2.2-2.

Table 3.2.2-1. **Chemical composition and mechanical properties of normal strength steel**

Grade		A			B			D			E		
Deoxidation practice for thickness t, mm		Killed or semi-killed			Killed or semi-killed			Killed			Killed, fine-grained, aluminium treated		
Condition of supply		According to Table 3.2.4-1											
Chemical composition (ladle analysis), %	C_{max}	0,21			0,21			0,21			0,18		
	Mn_{min}	2,5×C			0,80			0,60			0,70		
	Si_{max}	0,50			0,35			0,35			0,35		
	P_{max}	0,035			0,035			0,035			0,035		
	S_{max}	0,035			0,035			0,035			0,035		
	Al_{min}	–			–			0,015			0,015		
Tensile properties	Tensile strength R_m, MPa	400 – 520											
	Yield stress R_e, MPa, min	235											
	Elongation A_5, %, min	22											
Impact testing	Test temperature, ºC	+20			0			–20			–40		
	Plate thickness, t, mm	≤50	>50 ≤70	>70 ≤100	≤50	>50 ≤70	>70 ≤100	≤50	>50 ≤70	>70 ≤100	≤50	>50 ≤70	>70 ≤100
	Impact energy, min, J, longitudinal specimens, KV_L	–	34	41	27	34	41	27	34	41	27	34	41
	Impact energy, min, J, transverse specimens, KV_T	–	24	27	20	24	27	20	24	27	20	24	27

Notes to Table 3.2.2-1: 1. In case of the positive test results of the works' survey Grade A steel of 12,5 mm thickness may be rimmed.

2. Maximum 0,23 % carbon content for Grade A sections.

3. In case of the positive test results of the works' survey in the impact tested Grade B steel manganese content can be reduced to 0,60 %.

4. In case of the positive test results of the works' survey at the supply of steel of all grades slight deviations in the chemical composition are permitted after TM rolling, refer to **3.2.2**.

5. For Grade D steel over 25 mm thick.

6. For Grade D steel over 25 mm thick and Grade E steel the total aluminium content may be determined instead of acid soluble content. In such cases the total aluminium content shall be not less than 0,020 %. A maximum aluminium content may also be specified by the Register. In case of the positive test results of the works' survey other suitable grain refining elements may be used.

7. The Classification Society may limit the amount of residual elements which may have an adverse effect on the working and use of the steel (e.g. copper and tin).

8. Where additions of any other element have been made as part of the steelmaking practice, the content shall be indicated and agreed with the Register.

9. In case of the positive test results of the works' survey and statistical data justification for all thicknesses of Grade A sections the upper limit for the specified tensile strength range may be exceeded.

10. Refer to **3.2.3** and **3.2.6** for impact tests.

11. Charpy V-notch impact tests are generally not required for Grade B steel with thickness of 25 mm or less.

12. Impact tests for Grade A over 50 mm thick are not required when the material is produced using fine grain practice and furnished normalised. In case of the positive test results of the works' survey TM rolling may be accepted without impact testing.

13. Sampling tests may be carried out selectively for steel allowed for supply without impact tests. The results shall meet the relevant requirements of the Table, and for Grade A steel up to 50 mm thick, KV_L >27 J at 20°C.

14. For full thickness flat tensile test specimens with a width of 25 mm and a gauge length of 200 mm the elongation shall comply with the following minimum values:

Thickness t, mm	***t* ≤5**	**5< *t* ≤10**	**10< *t* ≤15**	**15< *t* ≤20**	**20< *t* ≤25**	**25< *t* ≤30**	**30< *t* ≤40**	**40< *t* ≤50**
Elongation, %	14	16	17	18	19	20	21	22

***Table 3.2.2-2*.** **Chemical composition and mechanical properties of higher strength steel**

Grade	**A32**	**D32**	**E32**	**A36**	**D36**	**E36**	**A40**	**D40**	**E40**
Deoxidation	Killed								
Condition of supply	According to Table 3.2.4-2								

Chemical composition (ladle analysis), %	C_{max}	0,18		
	Mn	0,9–1,6		
	Si_{max}	0,5		
	P_{max}	0,035		
	S_{max}	0,035		
	Cu_{max}	0,35		
	Cr_{max}	0,20		
	Ni_{max}	0,40		
	Mo_{max}	0,08		
	Al_{min}	0,015		
	Nb V Ti_{max}	0,02–0,05 0,05–0,10 0,02 (total ≤ 0,12)		
Tensile properties	Tensile strength R_m, MPa	440...570	490...630	510...660
	Yield stress R_{eH}, MPa	315	355	390
	Elongation A_5, min, %	22	21	20

Notes to Table3.2.2-2:

1. The letter "H" may be added either in front or behind the grade mark of higher strength steel (e.g. DH36).

2. Up to a thickness of 12,5 mm the minimum manganese content may be reduced to 0,70 %.

3. The total aluminium content may be determined instead of the acid soluble content. In such casesthe total aluminim content shall be not less than 0,020 %.

4. The steel shall contain aluminium, niobium, vanadium or other suitable grain refining elements, either singly or in any combination.

When used singly the steel shall contain the specified minimum content of the grain refining element according to Table 3.2.2-2.

When used in combination, the specified minimum content of a fine graining element is not applicable.

5. In case of the positive test results of the works' survey at the supply of higher strength steel of any grade in the TM rolled condition variations in the specified chemical composition may be permitted, refer to **3.2.2.3.**

When tensile tests of standard samples of full thickness, the minimum elongation shall correspond to the following values, %:

6. Refer to **3.2.2** and **3.2.6** for C_{eq} and P_{cm}.

7. Where additions of any other element have been made as part of the steelmaking practice, the content shall be indicated and agreed with the Register.

8. Refer to **3.2.3** and **3.2.6** for impact tests.

9. For Grades A32 and A36 steels a relaxation in the number of impact tests for acceptance purposes may be permitted, provided that satisfactory results are obtained from occasional check tests.

10. For full thickness flat tensile test specimens with a width of 25 mm and a gauge length of 200 mm the elongation shall comply with the following minimum values:

Grade of steel	**Thickness t, mm**							
	$t \le 5$	$5< t \le 10$	$10< t \le 15$	$15< t \le 20$	$20< t \le 25$	$25< t \le 30$	$30< t \le 40$	$40< t \le 50$
A32 **D32** **E32**	14	16	17	18	19	20	21	22
A36 **D36** **E36**	13	15	16	17	18	19	20	21
A40 **D40** **E40**	12	14	15	16	17	18	19	20

For steel plates and wide flats over 50 mm thick, slight deviations in the chemical composition of alloying elements may be allowed. Said deviations shall be justified and approved by the Register.

In Tables 3.2.2-1 and 3.2.2-2 the content of acid soluble aluminium is included. The total aluminium content shall be at least 0,020 %.

In case of the determination of the content of elements not listed in Tables 3.2.2-1 and 3.2.2-2, chromium, nickel and copper content in normal strength steel shall not exceed 0,30 % each.

For normal strength carbon steel the total carbon content plus 1/6 of the manganese content shall not exceed 0,40 %. The carbon equivalent, in %, for higher strength steels is calculated for guidance at approval tests from the ladle analysis using the formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}.$$

The arsenic content in steels of all the grades shall not exceed 0,08 %. The steel may contain separately or in combinations aluminium, vanadium, niobium or other grain refining elements.

Where the above elements are introduced separately, their content shall be in accordance with Tables 3.2.2-1 and 3.2.2-2.

Where the elements are used in combinations, their minimum content in steel is not specified.

Where the content of aluminium or another grain refining element proves to be lower than required, the Register may require the austenite grain size to be determined, which shall not be greater than grain size No. 5.

For higher strength steel subjected to the thermo-mechanical rolling (TM), the carbon equivalent shall be in compliance with the requirements of Table 3.2.2-3.

Table 3.2.2-3

Steel grades	Carbon equivalent, max, %	
	$t \leq 50$mm	50mm $< t \leq$ 100mm
A32, D32, E32, F32	0,36	0,38
A36, D36, E36, F36	0,38	0,40
A40, D40, E40, F40	0,40	0,42
Note: The value of the carbon equivalent shall be agreed upon between the Manufacturer and shipyard in each case.		

Instead of the carbon equivalent the factor estimating the steel susceptibility to cold cracking may be determined according to the formula:

$$P_{CM} = C + \frac{Si}{30} + \frac{Mn}{20} + \frac{Cu}{20} + \frac{Ni}{60} + \frac{Cr}{20} + \frac{Mo}{15} + \frac{V}{10} + 5B.$$

The maximum values of the carbon equivalent or P_{cm} are subject to an agreement with the Register and shall be shown in the steel technical documentation being approved. The actual values of C_{eq} or Pcm may be also shown in Manufacturer's and/or Register Certificates for steel being delivered. The austenitic grain size of steel shall be not less than 5 (ASTM E 112, GOST 5639).

The following microstructure parameters shall be determined:

for normal and higher strength steels with ferrite-pearlite structure the grain size shall not be larger than 8 - 9 in accordance with GOST 5639 (0,015-0,022 mm), ferrite/pearlite banding shall be no more than size 2 in accordance with GOST 5640 (scale 3, row A);

for higher strength steels with ferrite-bainite structure the ferrite grain size shall not be larger, than 9 - 10 in accordance with GOST 5639 (0,011-0,015 mm), structure anisotropy factor shall not be more than 1; the proportion and size of bainite areas with lath morphology shall also be determined.

Structure assessment criteria shall comply with the above standards or shall be equivalent to them in accordance with the approved documentation of the manufacturer.

3.2.3 Mechanical properties.

The mechanical properties of normal strength steel shall comply with the requirements given in Table 3.2.2-1 while the mechanical properties of higher strength steel shall comply with Table 3.2.2-2.

The impact energy at impact testing may be determined either on longitudinal KV_L, or transverse KV_T specimens.

Requirements for higher strength steel impact energy are given in Table 3.2.3.

Table 3.2.3

Steel grade	Temperature, °C	Average impact energy KV, min, J					
		$t \leq 50$ mm		50 mm $< t \leq$ 70 mm		70 mm $< t \leq$ 100 mm	
		KV_L	KV_T	KV_L	KV_T	KV_L	KV_T
A32	0	31	22	38	26	46	31
D32	–20	31	22	38	26	46	31
E32	–40	31	22	38	26	46	31
A36	0	34	24	41	27	50	34
D36	–20	34	24	41	27	50	34
E36	–40	34	24	41	27	50	34
A40	0	39	26	46	31	55	37
D40	–20	39	26	46	31	55	37
E40	–40	39	26	46	31	55	37

The testing shall be performed in compliance with the requirements given in Section **2**.

The testing shall be performed in compliance with the requirements given in Section 2. Values for standard specimens (10x10 mm) are given in tables on impact test. When rolled steel products with a thickness under 10 mm are presented, one shall be guided by the provisions set forth in **2.2.3.1**.

In general, the impact tests of delivered steel shall be performed on longitudinal specimens only (test results on transverse specimens shall be guaranteed by the manufacturer), with the exception of cases stipulated by the customer or the Register **1.3.4.2**.

3.2.4 Condition of supply.

The condition of steel supply shall meet the requirements of Tables 3.2.4-1 and 3.2.4-2 and shall be specified in a Manufacturer's Certificate.

3.2.5 Sampling.

Unless otherwise specified, the test samples shall be taken as follows:

the samples of plates and flats wider than 600 mm shall be taken from one end so that the sample axis is located midway between the longitudinal axis and the edge of the plate or flat (refer to Fig. 3.2.5-1);

the samples of flats 600 mm wide and less and of sections are taken from one end so that the sample axis lies 1/3 from the flat edge or from the outer edge of the section flange or, in the case of small sections, as near as possible to this position (refer to Figs. 3.2.5-2, 3.2.5-3 and 3.2.5-4);

in the case of channels, beams the test samples may be alternatively taken from the position 1/4 from the web centre line (refer to Fig. 3.2.5-3);

the samples of bars and similar semi-finished products are taken from one end so that the sample axis is parallel to the direction of rolling;

from rolled bars 50 to 150 m thick, samples are taken 1/4 of the thickness dimension from the surface.

Pieces of smaller cross-section may be tensile tested without prior machining.

In other cases, the samples shall be taken so that their axes lie:

for non-cylindrical semi-finished products, 1/3 of the half-diagonal from the outside (refer to Fig. 3.2.5-5);

for cylindrical semi-finished products, 1/3 of the radius from the outside (refer to Fig. 3.2.5-6).

Pieces selected for the preparation of tensile and impact test specimens shall be the thickest (greatest in diameter) in each batch with their longitudinal axes transverse to the final direction of rolling, except in the case of sections, bars and flats of 600 mm or less in width.

***Table 3.2.4-1*. Condition of supply for normal strength steel**[1]

Grade	Thickness, mm	Condition of supply
A	$t \leq 50$	Any
	$50 < t \leq 100$	Normalized (N), controlled rolled (CR) or thermo-mechanically rolled (TM)[2]
B	$t \leq 50$	Any
	$50 < t \leq 100$	Normalized (N), controlled rolled (CR) or thermo-mechanically rolled (TM)[2]
D	$t \leq 35$	Any
	$35 < t \leq 100$	Normalized (N), controlled rolled (CR) or thermo-mechanically rolled (TM)[3]
E	$t \leq 100$	Normalized (N) or thermo-mechanically rolled (TM)[3]

[1] The scope of impact tests is specified according to Table **3.2.6.4-1**.

[2] In case of the positive test results of the works' survey Grades A and B steel plates may be supplied in the as-rolled condition.

[3] Sections in Grade D steel may be supplied in the as rolled condition provided satisfactory results are consistently obtained from Charpy V-notch impact tests. Similarly sections in Grade E steel may be supplied in the as rolled or controlled rolled condition.

Specimens, on which impact energy KV shall be determined, shall be prepared with their longitudinal axes either parallel or transverse to the final direction of rolling of the material unless required in special cases that the samples are taken with their longitudinal axes transverse to the final direction of rolling.

The notch shall be cut perpendicular to the rolled surface and not closer than 25 mm to the flame cut or sheared edge.

The impact test specimens shall be taken within 2 mm below the rolled surface and where the thickness of the rolled material exceeds 40 mm - within 1/4 of the thickness (the axis of the specimens shall be in a plane located at 1/4 of the thickness and parallel to the surface).

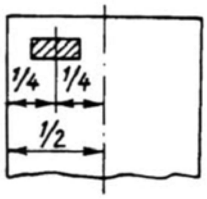


Fig.3.2.5-1. Plate and flat

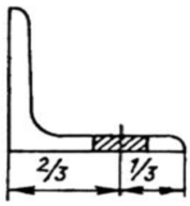


Fig.3.2.5-2. Angle

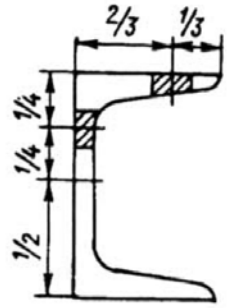


Fig.3.2.5-3. Channel and beam

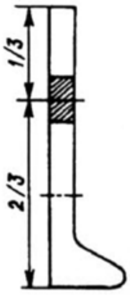


Fig.3.2.5-4. Bulb bar

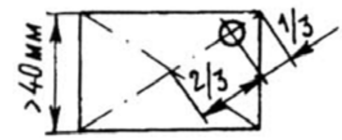


Fig.3.2.5-5. Rectangular bar

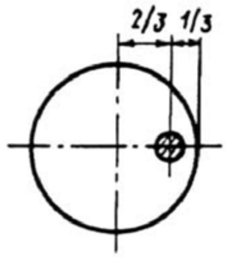


Fig.3.2.5-6. Cylindrical bar o

Table 3.2.4-2. **Condition of supply for higher strength steel**

Grade	**Grain refining elements**	**Thickness, mm**	**Condition of supply**
A32, A36	Nb and/or V	$t \leq 12{,}5$	Any
		$12{,}5 < t \leq 100$	Normalized (N), controlled rolled (CR) or thermo-mechanically rolled (TM)
A32, A36	Al or Al + Ti	$t \leq 20$	Any
		$20 < t \leq 35$	Any, subject to special approval if as rolled (AR)
		$35 < t \leq 100$	Normalized (N), controlled rolled (CR) or thermo-mechanically rolled (TM)
A40	Any	$t \leq 12{,}5$	Any
		$12{,}5 < t \leq 50$	Normalized (N), controlled rolled (CR) or thermo-mechanically rolled (TM)
D32, D36	Nb and/or V	$t \leq 12{,}5$	Any
		$12{,}5 < t \leq 100$	Normalized (N), controlled rolled (CR) or thermo-mechanically rolled (TM)
D32, D36	Al or Al + Ti	$t \leq 20$	Any
		$20 < t \leq 25$	Any, subject to special approval if as rolled (AR)
		$25 < t \leq 100$	Normalized (N), controlled rolled (CR) or thermo-mechanically rolled (TM)
D40	Any	$t \leq 50$	Normalized (N), controlled rolled (CR) or thermo-mechanically rolled (TM)
E32, E36	Any	$t \leq 50$	Normalized (N), controlled rolled (CR) or thermo-mechanically rolled (TM)
		$50 < t \leq 100$	Normalized (N), thermo-mechanically rolled (TM)
E40	Any	$t \leq 50$	Normalized (N), thermo-mechanically rolled (TM) or quenched and tempered (QT)

Note: Sections in Grades A32, A36, D32 and D36 steels may be supplied in as rolled condition, provided the results of impact tests are satisfactory. Similarly, sections in Grades E32 and E36 steels may be supplied in as rolled condition or after controlled rolling. The number of impact fests is determined according to **3.2.6.4-2**.

3.2.6 Number of tests.

3.2.6.1 Rolled material is presented for tests in batches. A batch shall comprise rolled products of the same type, from the same cast and in the same condition of supply. Unless otherwise specified, one tensile test piece and one set of impact test pieces shall be tested from each batch presented with the mass not exceeding 50 t (except Grade E, E32, E36 and E40 steel).

Where the batch mass is in excess of 50 t, one extra tensile and impact test shall be made for each 50 t or fraction thereof.

An additional test shall be made for every variation of more than 10 mm in the thickness of plates or for every variation of more than 10 mm in the thickness or diameter of sections and bars comprising the batch.

Samples for testing rolled material batches shall be taken from the thickest semi-finished product belonging to the batch concerned.

3.2.6.2 When the Register approves the supply of the material in the as-rolled condition, one set of impact test specimens shall be tested from each batch of 25 t or fraction thereof.

3.2.6.3 The number of impact tests for Grade E, E32, E36 and E40 steel shall be as follows: for plates and wide flats each piece shall be tested; for sections and bars one set shall be tested from each batch of 25 t or fraction thereof.

When, sections other than Grades E40 and F40 are supplied in the as rolled or controlled rolled condition, one set of impact tests shall be taken from each batch of 15 t or fraction thereof.

Table 3.2.6.4-1

<table>
<tr><th>Grade</th><th>Deoxidation</th><th>Type of rolled products</th><th colspan="5">Condition of supply (batch size for tests, KV)
Thickness, mm
10 12,5 20 25 30 35 40 50 100</th></tr>
<tr><td rowspan="3">A</td><td>Killed or semi-killed</td><td>Section</td><td>A(-)</td><td colspan="4">Not applicable</td></tr>
<tr><td rowspan="2"><50 killed or semi-killed, >50 killed</td><td>Plate</td><td colspan="4">A(-)</td><td>N(-),TM(-)
CR(50),AR*(50)</td></tr>
<tr><td>Section</td><td colspan="4">A(-)</td><td>Not applicable</td></tr>
<tr><td rowspan="2">B</td><td rowspan="2"><50 killed or semi-killed, ≥50 killed</td><td>Plate</td><td colspan="4">A(50)</td><td>N(50), TM(50)
CR(25), AR*(25)</td></tr>
<tr><td>Section</td><td colspan="2">A(-)</td><td colspan="2">A(50)</td><td>Не регламентується</td></tr>
<tr><td rowspan="3">D</td><td>Killed</td><td>Plate, Section</td><td colspan="2">A(50)</td><td colspan="3">Not applicable</td></tr>
<tr><td rowspan="2">Killed and fine-grained</td><td>Plate</td><td colspan="3">A(50)</td><td>N(50) CR(50)
TM(50)</td><td>TM(50) N(50)
CR(25)</td></tr>
<tr><td>Section</td><td colspan="3">A(50)</td><td>N(50)
CR(50) TM(50)
AR*(25)</td><td>Not applicable</td></tr>
<tr><td rowspan="3">E</td><td rowspan="3">Killed and fine-grained</td><td>Plate</td><td colspan="5">N (each piece)
TM (each piece)</td></tr>
<tr><td></td><td colspan="5"></td></tr>
<tr><td>Section</td><td colspan="4">N(25), TM(25),
AR*(15),CR*(15)</td><td>Not applicable</td></tr>
</table>

Symbols: A – any; N – normalizing; CR – controlled rolling; QT – quenching and tempering. *Note.:* AR* as-rolled steel and CR* controlled rolling specified in the present table and in Table 3.2.6.4-2 may be applied in case of the positive test results of the works' survey..

Impact tests of the rolled materials after quenching and tempering (QT) shall be carried out on each length undergone such operation. The number of impact tests of the rolled materials, agreed with the Register, which may be accepted for supply in hot-rolled condition, may be increased.

The maximum size of the batch, from which a set of specimens is taken, shall be 25 t.

3.2.6.4 In general, the number impact tests is given in Tables 3.2.6.4-1 and 3.2.6.4-2.

Table 3.2.6.4-2

Steel grade	**Deoxidation**	**Grain refining elements**	**Type of rolled products**	**Condition of supply (batch size for tests, KV)** **Thickness, mm** 10 12,5 20 25 30 35 40 50 100		
1	**2**	**3**	**4**	**5**		
A32, A36	Killed and fine-grained	Nb and or V	Plate	A(50)	N(50), CR(50), TM(50)	N(50),CR(25),TM(50)
			Section	A(50)	N(50), CR(50), TM(50), AR*(25)	Not applicable
		A1 or Al+Ti	Plate	A(50)	AR*(25)	Not applicable
					N(50), CR(50), TM(50)	N(50), CR(25),TM(50)
			Section	A(50)	N(50), CR(50) TM(50), AR*(25)	Not applicable
A40		Будь-які	Plate	A(50)	N(50) CR(50), TM(50)	N(50) TM(50) QT(each length as heat treated)
			Section	A(50)	N(50), CR(50), TM(50)	Not applicable
D32, D36		Nb or V	Plate	A(50)	N(50), CR(50), TM(50)	N(50),CR(25),TM(50)
			Section	A(50)	N(50), CR(50), TM(50), AR*(25)	Not applicable
		A1 or Al+Ti	Plate	A(50)	AR	Not applicable
					N(50), CR(50), TM(50)	N(50), CR25, TM(50)
			Section	A(50)	N(50), CR(50), TM(50), AR*(25)	Not applicable
D40		Any	Plate	N(50), CR(50), TM(50)		N(50), TM(50) QT(each length as heat treated)
			Section	N(50), CR(50), TM(50)		Not applicable
E32, E36		Any	Plate	N (each piece), TM (each piece)		
			Section	N(25), TM(25), AR*(15),CR*(15)		Not applicable
E40		Any	Plate	N (each piece) TM (each piece) QT (each length as heat treated)		N (each piece) TM (each piece) QT (each length as heat treated)
			Section	N(25), TM(25), QT(25)		Not applicable
F32, F36		Any	Plate	N (each piece) TM (each piece) QT (each length as heat treated)		N (each piece) TM (each piece) QT (each length as heat treated)
			Section	N(25), TM(25), QT(25), CR*(15)		Not applicable
F40		Any	Plate	N (each piece) TM (each piece) QT (each length as heat treated)		N (each piece) TM (each piece) QT (each length as heat treated)
			Section	N(25), TM(25), QT(25)		Not applicable

3.2.6.5 Where the ultrasonic testing shall be performed as required by conditions of supply, such a testing shall be carried out in accordance with the Register-recognized international or national standard.

The ultrasonic testing is the responsibility of the manufacturer.

Technical supervision during the testing shall not absolve the manufacturer from this responsibility.

3.2.7 Inspection.

Segregations and non-metallic inclusions must comply the adopted rules.

The semi-finished products shall be free from cracks, slag inclusions and other defects prejudicial to the use of the material for its intended application.

The semi-finished products shall also have workmanlike surface and shall not have been hammer dressed.

The manufacturer shall guarantee complete elimination of piping, which shall be verified by check tests. The methods of testing shall be agreed with the Register.

Surface defects may be removed by local grinding, provided the nominal thickness is in no place reduced by more than 7 %, but in no case by more than 3 mm.

The total area rectified by grinding shall not exceed 2 % of the product surface.

Surface defects, which cannot be removed by local grinding, may be repaired by chipping or grinding followed by welding, subject to the Register consent and under its technical supervision, provided that:

after removal of the defects before welding the thickness of the product is in no place reduced by more than 20 %;

welding is carried out in accordance with an approved procedure by qualified welders with approved electrodes;

the welded area is ground smooth to the correct nominal thickness;

the area of a single welding shall not exceed 25 cm^2;

the total welded area shall not be greater than 1 % of the product surface;

after welding surface defects the advisability and type of heat treatment, if required, are agreed with a surveyor to the Register.

3.2.8 Thickness tolerances of steel plates and wide flats.

3.2.8.1 Application..

These requirements apply to the tolerance on thickness of steel plates and wide flats with widths of 600 mm or greater with thicknesses of 5 mm and over, covering the following steel grades:

.1 normal and higher strength hull structural steels according to **3.2**;

.2 high strength hull structural steels according to **3.13**;

.3 steels for machinery structures.

The thickness tolerances for steel plates and wide flats below 5 mm may be taken from national or international standards, equivalent to Class B (ISO 7452). In this case, minus tolerance shall not exceed 0,3 mm.

These requirements do not apply to rolled steel products intended for the constructions of boilers, heat exchangers, pressure vessels, etc., as well as independent tanks for the transportation of liquefied gases or chemicals.

Class C (ISO 7452-2013) or equivalent according to national or international standards may be applied in lieu of 3.2.8.3, in which case the requirements in **3.2.8.4** and **3.2.8.5** need not be applied.

If Class C (ISO 7452-2013) is applied, the footnote Table 2 part of which reads: "Also a minus side of thickness of 0,3 mm is permitted.", is not applicable.

Additionally, if class C ISO 7452is applied, it is required that the steel mill demonstrate to the satisfaction of the Register that the number of measurements and measurement distribution is appropriate to establish that the mother plates produced are at or above the specified nominal thickness.

3.2.8.2 Responsibility.

The responsibility for verification and maintenance of the production within the required tolerances rests with the manufacturer. The surveyor to the Register may require to witness some measurements.

The responsibility for storage and maintenance of the delivered product(s) with acceptable level of surface conditions rests with the shipyard before the products are used in fabrication.

3.2.8.3 Thickness tolerances.

The tolerances on thickness of a given product are defined as:

.1 minus tolerance is the lower limit of the acceptable range below the nominal thickness;

.2 plus tolerance is the upper limit of the acceptable range above the nominal thickness.

Note: Nominal thickness is defined by the purchaser at the time of enquiry and order.

The minus tolerance on thickness of steel rolled products of normal and higher strength according to **3.2**, of high strength according to **3.13**, as well as steels supplied in accordance with the requirements of **3.14** and Part XII "Materials" of the Rules for the Classification, Construction and Equipment of Mobile Offshore

Drilling Units and Fixed Offshore Platforms shall be 0,3 mm or less irrespective of nominal thickness.

The minus tolerances for products for machinery structures shall be in accordance with Table3.2.8.3.

The tolerances on nominal thickness, specified in Table 3.2.8.3, are not applicable to areas repaired by grinding. For such areas the requirements of 3.2.7.4 may be applied unless stricter requirements as per a recognized standard are considered by the Register or purchaser.

The plus tolerances on nominal thickness shall be in accordance with a recognized national or international standard unless required otherwise by the Register or purchaser.

Table 3.2.8.3

Nominal thickness t, mm	**Tolerance, mm**
$3 \leq t < 5$	–0,3
$5 \leq t < 8$	–0,4
$8 \leq t < 15$	–0,5
$15 \leq t < 25$	–0,6
$25 \leq t < 40$	–0,7
$40 \leq t < 80$	–0,9
$80 \leq t < 150$	–1,1
$150 \leq t < 250$	–1,2
$250 \leq t$	–1,3

3.2.8.4 Average thickness.

The average thickness of a product or products is defined as the arithmetic mean of the measurements made in accordance with **3.2.8.5**.

The average thickness of steel rolled products of normal and higher strength according to **3.2**, of high strength according to **3.13**, as well as steels supplied in accordance with the requirements of **3.14** and Part **XII** "Materials" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms shall not be less than the nominal thickness.

3.2.8.5 Average thickness measuring locations. At least two lines among shown in Fig. 3.2.8.5 and 3.2.8.5.1, shall be selected for the thickness measurements and at least three points on each selected line shall be selected for thickness measurement.

If more than three points are taken on each line the number of points shall be equal on each line.

3.2.8.5.1 Average thickness measuring locations.

At least two lines among shown in Fig. 3.2.8.5 and 3.2.8.5.1, shall be selected for the thickness measurements and at least three points on each selected line shall be selected for thickness measurement. If more than three points are taken on each line the number of points shall be equal on each line.

For automated methods, the measuring points at sides shall be located not less than 10 mm but not greater than 300 mm from the transverse or longitudinal edges of the product.

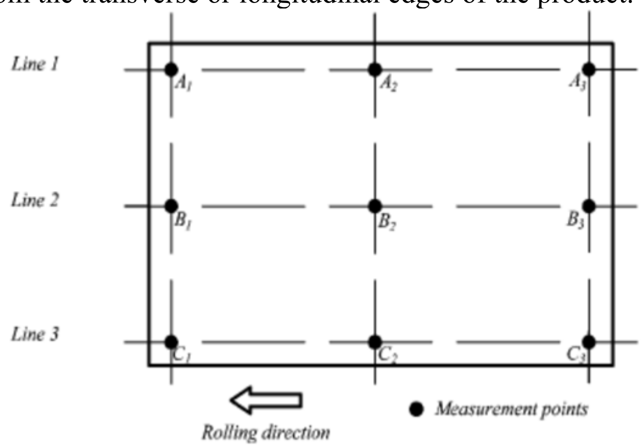


Fig. 3.2.8.5. Locations of thickness measuring points for the original steel plates.

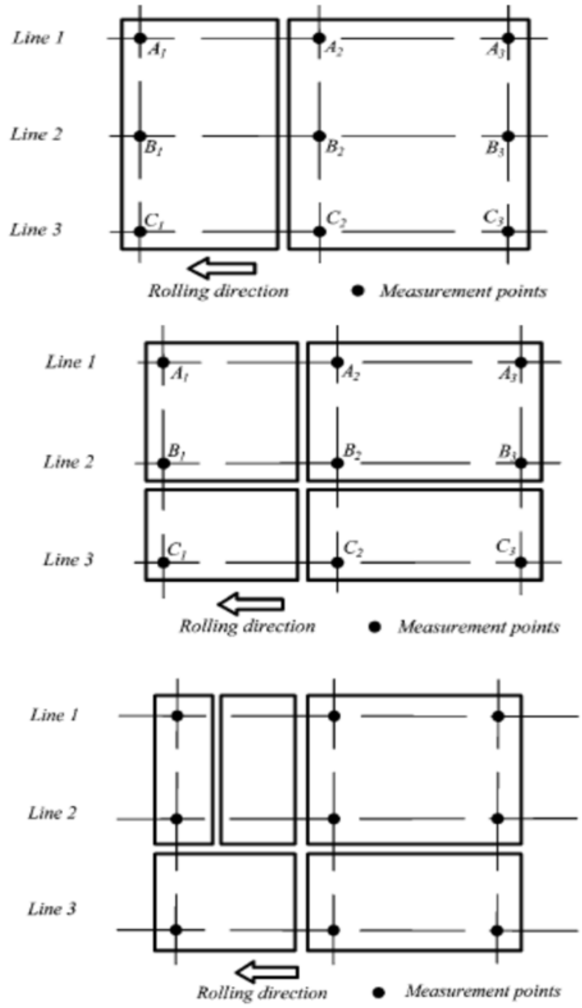


Fig. 3.2.8.5.1 Locations of thickness measuring points for the cut steel products

For manual methods, the measuring points at sides shall be located not less than 10 mm but not greater than 100 mm from the transverse or longitudinal edges of the product.

Note: The measurement locations apply to a product rolled directly from one slab or steel ingot even if the product shall be later cut by the manufacturer. Examples of the original measurements relative to later cut products are shown in Fig. 3.2.5.8.1. It shall be noted that the examples shown are not representative of all possible cutting scenarios.

3.2.9 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of 1.4.

Every semi-finished product shall have clearly visible stamp or brand of the Register marked by the specified method and in specified location.

Besides the mentioned above, the marking shall include the unified indication mark for grade of steel and strength level (e.g., A, D36, E450).

If the steel is supplied after heat treatment, at the request of the Register, an index «TMCP» shall be added after the identification mark (e.g., E36TMCP).

Besides, the steel, supplied under the Register technical supervision may have index “PУ” before the unified identification mark for grade of steel and strength level (e.g., PУE36TMCP).

In case of the Register approved supply of steel, which does not fully comply with the requirements of the Rules (refer to **3.2.1.1**), index "S" may be added after the identification mark for grade of steel and strength level (e.g., PУE36STMCP або PУD36S).

Branding of rolled and section rolled steel products may be performed on a label. At that the manufacturer shall confirm the identification system of every rolled product in a bundle.

3.3 STEEL FOR BOILERS, HEAT EXCHANGERS AND PRESSURE VESSELS

3.3.1 General.

3.3.1.1 The present requirements are applicable to rolled steel for marine boilers, heat exchangers and pressure vessels under the survey by the Register.

3.3.1.2 The steel manufactured in accordance with national and international standards or other technical documentation shall meet the requirements of this Chapter.

3.3.1.3 Rolled steel which is manufactured and tested in accordance with these requirements is intended for operation at room or elevated temperatures.

3.3.2 Chemical composition.

3.3.2.1 The chemical composition of steel shall be in accordance with standards proceeding from the required mechanical properties at room or elevated design temperatures and the content of base elements in % shall not exceed:

for carbon and carbon-manganese steels (ladle analysis), %:

carbon - 0,20, phosphorus and sulphur - 0,04, silicon - 0,50, manganese - 1,60, chromium, nickel, copper - 0,30.

The use of steel with carbon content more than 0,20 % for welded structures shall be agreed with the Register on condition sufficient weldability is ensured;

for low-alloy steel (ladle analysis), %: carbon - 0,18, phosphorus - 0,04, silicon - 0,50, chromium - ,50, manganese - 0,80, molybdenum - 1,10, sulphur - 0,04, vanadium - 0,35

3.3.2.2 The steel shall be killed. Using of rimming steel is not permitted and using of semi-killed steel is not recommended and shall be approved by the customer. Treatment of steel with grain-refining elements may be permitted within the limits specified in the national and international standards recognized by the Register.

Carbon and carbon-manganese steel intended to operate at temperatures over 400°C shall not contain aluminium.

3.3.2.3 On agreement with the customer using of steel complying with national and international standards recognized by the Register may be permitted.

3.3.3 Mechanical properties.

The mechanical properties of steel at room and elevated temperature shall be in accordance with standards. The properties of steel shall be confirmed by the following tests:

tensile test (tensile strength, yield stress and elongation are determined);

bend test;

impact test (KCU or KV).

The tensile test at elevated temperature and the ageing test shall be carried out if required by the relevant parts of the Rules or by standards.

The values of long-term stress-rupture strength of metal shall be submitted to the Register.

3.3.4 Heat treatment.

The steel shall be manufactured as normalized, normalized and tempered or quenched and tempered. The method of heat treatment shall be as stipulated by standards.

Provided the required properties are ensured and confirmed by tests and statistical data, steel may be manufactured without heat treatment, and controlled temperature rolling may be accepted as a substitute for normalizing.

3.3.5 Sampling.

Unless stated otherwise, sampling shall be carried out in accordance with **3.2.5**.

Tensile test specimens and those for determining the impact toughness KCU shall be cut out transverse to, and those for determining the impact energy KV - parallel to the direction of the last rolling.

3.3.6 Number of tests.

Each rolled steel plate shall be submitted for testing. In the case of rolled plates of carbon steel up to 12 mm thick, as well as rolled sections, it is permitted to take 10 % of the total number of the plates (rolled pieces) or sections for testing purposes, but not less than two and of the same thickness (diameter or shape), one and the same cast and identical heat treatment.

Unless stated otherwise, not less than one specimen for tensile and bend testing and not less than one set of specimens for impact testing shall be taken from the rolled piece intended for testing purposes.

From plates (rolled pieces) with a mass of more than 6 t or a length of more than 15 m the samples for test specimens shall be cut out on both ends.

3.3.7 Inspection.

The rolled steel shall be free from defects prejudicial to the use of the material for the intended application.

Freedom from non-allowable defects shall be guaranteed by the manufacturer and may be confirmed by the results of non-destructive testing.

Surface defects involved by the manufacturing process are permitted in case their depth is not greater than the allowable under-thickness tole-rances, considering from the nominal thickness.

Repair of surface defects by welding followed by post-weld heat treatment is permitted using the technology approved by the Register.

3.3.8 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of **1.4**.

Every semi-finished product shall have clearly visible stamp or brand of the Register marked by the specified method and in specified location.

Branding of rolled and section rolled steel products may be performed on a label.

At that the manufacturer shall confirm the identification system of every rolled product in a bundle.

3.4 STEEL STRUCTURAL TUBES

3.4.1 General.

3.4.1.1 The present requirements apply to hot- and cold-formed steel tubes and welded tubes intended for manufacture of hull structures subject to survey by the Register.

3.4.1.2 Steel structural tubes shall comply with the requirements of this Chapter and be manufactured in accordance with international and national standards or technical documentation approved by the Register.

3.4.1.3 The welded pipes and tubes shall be manufactured by means of electric induction welding, pressure contact welding or fusion welding.

3.4.2 Chemical composition.

3.4.2.1 The chemical composition of the steel for pipes and tubes shall be chosen on the basis of standards proceeding from the required mechanical properties at room of elevated design temperature; the content of base elements in per cent shall not exceed the values stated below:

for carbon and carbon-manganese steels (ladle analysis), %:

sulphur and phosphor — 0.04, manganese — 1.50, chromium, nickel, silicon — 0.50, copper — 0.30, carbon — 0.23;

for low-alloy steel (ladle analysis), %:

sulphur and phosphor — 0.035, manganese — 1.00, chromium — 2.50, silicon — 0.50, molybdenum — 1.20, carbon — 0.20, vanadium — 0.35.

3.4.2.2 The steel shall be killed. Rimming steel is not permitted for manufacturing pipes and tubes and semikilled steel is permitted on agreement with the Register. On agreement with the Register, the steel may be treated with grain-refining elements. Carbon and carbon-manganese steel intended for working temperatures above 400°C shall not contain aluminium.

3.4.2.3 The use of steel, in which the base elements content exceeds the above limits as well as steel containing other base alloying elements than those stated above, may be permitted on agreement with the Register.

3.4.2.4 The chemical composition shall be determined from the heat analysis (ladle analysis); determination of chemical composition on a tubular billet is permitted.

3.4.3 Mechanical and technological properties.

3.4.3.1 Mechanical and technological properties of steel intended for tubes at room and elevated design temperature shall be in accordance with standards for tubes.

3.4.3.2 In the process of manufacture the pipes and tubes shall undergo the following tests: tensile test (tensile strength, yield stress and elongation being determined) according to **2.2.2**;

tensile test at elevated temperature (proof stress being determined);

test according to **2.2.5.2**, or

tensile test of rings according to **2.2.5.4**;

expanding test according to **2.2.5.3**.

Tensile test at elevated temperature, flattening test, tensile test of rings and expanding test shall be carried out when required by standards for pipes or by technical documentation approved by the Register on the basis of which the test results are estimated.

When required by the Register or provided for by the relevant parts of the Rules or by standards, the results of testing the steel intended for pipes and tubes for determining the average stress to produce rupture at elevated temperature shall be submitted.

3.4.4 Heat treatment.

The tubes shall be subject to heat treatment, when stipulated by the relevant parts of the Rules, by standards or technical design documentation approved by the Register. The cold-formed and electrically welded tubes shall in any case be heat treated, normalized, normalized and tempered or quenched and tempered. The method and conditions of heat treatment shall be chosen by the manufacturer, reported to the Register and stated in the certificate.

3.4.5 Sampling.

Unless stated otherwise, sampling for specimens shall be made from one end of not less than two pipes or tubes of the batch.

3.4.6 Number of tests.

The pipes and tubes shall be tested by batches. A batch shall consist of pipes and tubes of the same size manufactured from steel of the same heat and heat treated under similar conditions. The number of pipes or tubes in a batch shall not exceed:

400 in the case of pipes or tubes with an outer diameter of 76 mm or less;

200 in the case of pipes or tubes with an outer diameter over 76 mm.

A rest of pipes or tubes, which is less than half the number stated, shall be included in a relevant batch and one which is half and over, — shall be considered a separate batch.

For testing purposes, out of each sample 1 specimen for the tensile test,

1 specimen for the flattening test or the tensile test of rings (when welded pipes and tubes are tested — 2 specimens, during the testing of one of the specimens the welded joint shall be in the tension zone),

1 specimen for the expanding test shall be cut.

All the pipes and tubes shall be tested by hydraulic pressure. The test pressure shall be in accordance with standards for pipes and tubes or with documentation agreed with the Register, but in any case it shall not be less than that stated in **21.2**, Part VIII “Systems and Piping” and in **1.7**, Part X “Boilers, Heat Exchangers and Pressure Vessels”.

On agreement with the Register, hydraulic tests may be omitted if all the pipes and tubes undergo ultrasonic or other equivalent testing.

All the welds in welded pipes and tubes shall undergo the ultrasonic testing.

3.4.7 Inspection.

All the pipes and tubes shall undergo visual testing.

The surface of the pipes and tubes shall be free from cracks, skins, fissures and laps.

A certain number of minor nicks and dents, marks, thin layers of scale, traces of defects grinding and small skins are permitted if due to them the wall thickness would not exceed the allowable underthickness tolerances.

3.4.8 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of 1.4.

Branding of pipes may be performed on a label. At that the manufacturer shall confirm the identification system of every rolled product in a bundle.

3.5 STEEL FOR STRUCTURES USED AT LOW TEMPERATURES

3.5.1 General.

3.5.1.1 The present requirements apply to steel plates, flats, sections and bars up to 100 mm thick, as well as to forgings and castings intended for ship's hull structures, equipment and machinery intended for use at design temperatures below - 30°C.

3.5.1.2 Application of requirements for rolled products, forgings and castings intended for use at design temperatures below - 50°C is permitted, taking into account the requirements of 3.5.3 and 3.5.4, as well as crack and cold resistance test results submitted by the works.

The requirements for rolled products depending on the strength level specified and operation conditions are given in **3.2**, **3.13**, **3.14** and **3.17** of this Part, and in **4.2** and **4.3**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP (for steel of improved weldability).

The requirements for the rolled products with thickness of 15 mm or less designed for operation at design temperatures below - 30°C are specified in **3.5.2.6**.

The requirements for Grade F steel rolled products are given in **3.5.2**.

The requirements for the manufacture, inspection, identification, marking and documentation for rolled products, forgings and castings are given in **3.2**, **3.7** and **3.8** accordingly.

3.5.1.3 The rolled products, forgings and castings shall be manufactured by the firms recognized by the Register in accordance with **1.3**.

3.5.1.4 Steel other than specified in this Chapter as to the chemical composition, mechanical properties and condition of supply may be allowed for use in compliance with the national and international standards recognized by the Register.

3.5.1.5 Where provision is made for welding during the manufacture of forged or cast items, or where such items are intended for welding inside the ship's hull, the chemical composition of steel and the welding procedure shall ensure the welded joint resistance to cracking.

The mechanical properties and impact energy of weld metal at the specified temperature at impact test shall be not lower than those required for the base metal.

3.5.1.6 Steel rolled products in plates, flats, sections, as well as steel forgings and castings for hull structural members, equipment and machinery subjected to long-term exposure to low temperatures are selected with due regard for the set value of the structure design temperature and the structural member category. The structure design temperature T_D and the structural member category are determined according to **1.2.3**, Part II "Hull" and the additional requirements and restrictions specified in this Chapter for higher and high strength steels for category III according to Table 3.5.1.6.

3.5.1.7 For hull structural members of icebreakers with sign **Icebreaker** in class notation and ships with Polar classes **PC1 – PC7**, Balnic class signs **IA Super** – **IC** and Register ice classes **Ice4**, **Ice5** and **Ice6**, the design temperature T_D of which does not exceed - 30°C, use of steel of improved weldability is permitted(refer to **4.2**, **4.3**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP).

If it is necessary to use rolled steel with a thickness not exceeding, specified in 3.5.1.6, the Register may require the use of steel that meets special requirements for toughness and cold resistance - steel with the upper index "Ice" (refer toe 3.5.2.1). In the latter case, the condition for the use of the material in these structures is $T_d < T_D$, where T_d.

3.5.1.8 Steel is tested in accordance with the requirements of Section 2 with the use of the Registerapproved programs. Tests to determine T_d are carried out, as a rule, within the operating temperature range including temperature T_D.

For details - refer to **3.5.2**, **3.5.4** and **3.5.5**.

3.5.1.9 Given the satisfactory results of testing according the Register programs in the initial survey of rolled products manufacture (issue of a Recognition Certificate for Manufacturer), the range of steel application as compared with that in **3.5.1.6** of this Chapter, **1.2.3**, Part II "Hull" of this Rules and **1.5**, Part II "Hull" of the Rules for the Classification, Construction and Equipment of MODU/FOP, may be extended.

Table 3.5.1.6

Steel grade	**Design temperature T_D, °C**		
	Thickness of structural member wall, max, mm		
	-30	-40	-50
D 32, D36	15	10	-
E32, E36W	35	25	15
E32W	45	30	20
F32	80	60	40
F32W, F36W	будь-яка	70	50
E36, E40W, E420W, E460W	30	20	15
F36, F40	60	40	30
D40, D420	10	-	-
E40, E420, E460, E500W	25	15	10
F40W, F420W, F460W	80	50	35
F420W, F460, F500W	50	35	25
E500	20	15	10
F500	50	30	20
Note: For the use of steel in conditions not regulated herein refer to **3.5.1.**7			

3.5.2 Hull structural steel.

3.5.2.1. General.

The present requirements apply to Grade F steel plates, flats, sections and bars up to 100 mm thick. The requirements for steel plates marked with upper index «**Ice**» are also included.

The general requirements for steel are given in **3.2.1**.

Unless otherwise specified, the rate of plastic deformation in rolling shall be 5:1 as a minimum. The requirements for the rolled products with thickness of 15 mm or less designed for operation at design temperatures below -30°C are specified in **3.5.2.6**.

3.5.2.2 Хімічний склад.

Chemical composition and structure. The chemical composition of steel is specified in standards and technical requirements and shall not exceed the ultimate values given in Table 3.5.2.2 for higher strength steel and in Table 3.13.2 for high strength steel. Higher strength steel of improved weldability as to chemical composition shall meet the requirements of Tables **4.2.1.2** and **4.2.2**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP.

The steel shall be fully killed and treated with grain-refining elements.

Table 3.5.2.2. **Chemical composition of hull structural steel**

Steel grade	**Content of elements, %**													
	C	Mn	Si	P	S	Al, acidsoluble, min	Nb	V	Ti	Cu	Cr	Ni	Mo	N
	max		max						max					
F32	0,16	0,90–1,60	0,50	0,025	0,025	0,015	0,02–0,05	0,05–0,10	0,02	0,35	0,20	0,80	0,08	
F36	0,16	0,90–1,60	0,50	0,025	0,025	0,015	0,02–0,05	0,05–0,10	0,02	0,35	0,20	0,80	0,08	N[1]
F40	0,16	0,90–1,60	0,50	0,025	0,025	0,015	0,02–0,05	0,05–0,10	0,02	0,35	0,20	0,80	0,08	
							Total content 0,12 max							

[1] N= 0,009 (0,012 – if Al is present

Notes: 1. Total content of aluminium may be determined instead of determination of the content of acid-dissolved aluminium. In this case, total content of aluminium shall be not less than 0.020 %.

2. Steel may be treated with aluminium, columbium, vanadium or other appropriate grain refining elements, separately or in any combination. In this case, if one element is introduced, its content shall comply with the table, and if treatment with combination of elements is used, content of at least one of them shall be in accordance with the table.

The following microstructure parameters shall be determined:

for higher strength steels with ferrite-pearlite structure the grain size shall not be larger than 8 - 9 in accordance with GOST 5639 (0,015 - 0,022 mm), ferrite/pearlite banding shall be no more than size 2 in accordance with GOST 5640 (scale 3, row A);

for higher strength steels with ferrite-bainite structure the ferrite grain size shall not be larger than 9 - 10 in accordance with GOST 5639 (0,011 - 0,015 mm), structure anisotropy factor shall not be more than 1;

the portion and size of bainite areas with lath morphology shall also be determined;

for strengthened bainite-martensite steels the austenite grain size shall not be larger than 6 - 7 in accordance with GOST 5639 (0,031 - 0,044 mm).

Structure assessment criteria shall comply with the above standards or shall be equivalent to them in accordance with the approved documentation of the manufacturer.

3.5.2.3 Mechanical properties.

The mechanical properties of Grades F32, F36 and F40 steels during tensile test and impact test shall meet the requirements of Table 3.5.2.3; the mechanical properties of Grades F420, F460, F500, F550, F620 and F690 steels shall meet the requirements of **3.13.3**.

Additionally to **3.2.5**, tests for determining impact energy in the specimens cut out from the plate midthickness are carried out for steel over 40 mm thick. In this case the test results shall also meet the requirements of Tables 3.5.2.3 and 3.13.7-1.

Table 3.5.2.3. **Mechanical properties of hull structural steel**

Grade	Yield stress R_{eH}, MPa, min	Tensile strength R_m, MPa	Elongation A_5, %, min	Impact test						
				Test temperature, °C	Average impact energy value KV, min, J					
					t ≤ 50 mm		50< t ≤70 mm		70< t ≤100 mm	
					KV_L	KV_T	KV_L	KV_T	KV_L	KV_T
F32	315	440–590	22	–60	31	22	38	26	46	31
F36	355	490–620	21	–60	34	24	41	27	50	34
F40	390	510–650	19	–60	39	26	46	31	55	37

3.5.2.4 Condition of supply.

Condition of steel supply: for Grades F32, F36 and F40 - according to the requirements of Table 3.2.6.4; for Grades F420, F460, F500, F550, F620 and F690 - according to the requirements of **3.13.4.**

3.5.2.5 Requirements for steel plates of grade marked with upper index «**Ice**»

3.5.2.5.1 «**Ice**» is the symbol added to the designation of steel grade for which additional tests were performed according to the Register programs to determine ductility and cold resistance characteristics (refer to **2.2.10**, **3.5.1.9**, **3.5.2.5.6**) and and meeting the relevant requirements for steels of improved weldability according to Section **4**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP and the requirements for Z-properties. The minimum material service/ operating temperature Td (without the minus sign) down to which the steel may be used for any structural members without limitations shall be indicated next to the symbol (e.g., F36W^{Ice40} or F36W^{Ice40}).

3.5.2.5.2 The chemical composition of higher strength steel marked with upper index «**Ice**», shall meet the relevant requirements for steel of improved weldability.

The chemical composition of high strength steel marked with upper index «**Ice**», shall meet the requirements of the Register-approved documentation.

The sulphur content shall not exceed 0,008 %, the phosphorus content, 0,015 %.

3.5.2.5.3 The mechanical properties of steel shall meet the requirements for the steel of a relevant grade according to **3.2**, **3.13**, **3.14** and **3.17**. In this case, the test program during the initial survey of manufacture by the Register in accordance with **1.3.1.2** in order to determine the possibility of adding upper index «**Ice**», to a steel grade includes the following:

1. determining the temperature of a ductile-brittle transition to estimate the material property with regard to retarding the spread of brittle failure (T_{kb}, *NDT, DWTT)*;

tests for determining the temperature T_{kb} are carried out according to **2.2.10.2;**

tests for determining the temperature NDT are carried out according to **2.2.10.3**;

tests for determining the temperature DWTT are carried out according to **2.2.10.4**;

.2 determining the crack resistance parameter CTOD for the base metal and HAZ metal in testing the specimens cut from butt-welded joints:

tests for determining the crack resistance parameter CTOD for the base metal are carried out according to **2.2.10.5**;

tests for determining the crack resistance parameter CTOD for the HAZ metal are carried out according to **2.2.10.6**.

Application of each of the above procedures during tests shall be agreed with the Register in each particular case.

Where one procedure for steel manufacture is concerned (smelting, rolling, condition of supply), the results of the above tests obtained with the thickest rolled products may be extended to the rolling products of less thickness.

3.5.2.5.4 The average value of CTOD for base metal shall be not less than that specified in Table 3.5.2.5.4 with the minimum value at least 0,7 of the required one. The lowest test temperature at which the Table 3.5.2.5.4 requirements are met, is assumed to be the minimum temperature $T_{d\ (CTOD)}$ for the given type of tests.

Table 3.5.2.5.4 **Requirements for CTOD value for base metal, mm**

Thickness, mm	Strength level (required minimum value of yield stress, MPa)					
	normal	315-355	390-420	460-500	550-620	690
25 ÷ 35	-	0,15	0,15	0,20	0,20	0,25
36 ÷ 50	0,15	0,20	0,20	0,25	0,25	0,30
51 ÷ 70	0,20	0,20	0,25	0,30	0,30	0,35
>70	0,20	0,25	0,25	0,30	0,35	0,35

3.5.2.5.5 The average value of CTOD for the HAZ metal shall be not less than that required by Table 3.5.2.5.5 with the minimum value at least 0,5 of the required one. If the number of correct tests is increased up to five and more, the lowest result may be ignored.

The lowest test temperature at which the Table 3.5.2.5.5 requirements are met, is assumed to be the minimum temperature $T_{d\ (CTODHAZ)}$ for the given type of tests.

Table 3.5.2.5.5 **Requirements for CTOD value for HAZ metal, mm**

Thickness, mm	Strength level (required minimum value of yield stress, MPa)					
	normal	315-355	390-420	460-500	550-620	690
25 ÷ 30	-	0,10	0,10	0,10	0,15	0,20
31 ÷ 50	0,10	0,10	0,15	0,15	0,20	0,25
>50	0,10	0,15	0,20	0,20	0,25	0,30

3.5.2.5.6 Based on the results of *NDT*, T_{kb} and *DWTT* the temperatures ($T_{d\ (NTD)}$, $T_{d\ (Tkb)}$, $T_{d\ (DWTT)}$), are determined, the greatest of all the values is $T_{d\ (b\text{-}d)}$, assumed to be the ductile-brittle transition temperature T_{kb} of the sampling steel. Depending on the rolled products thickness the required temperature values $T_{d\ (NTD)}$, $T_{d\ (Tkb)}$, $T_{d\ (DWTT)}$ for the steel marked with upper index «**Ice**», are given in Table 3.5.2.5.6**.**

Table 3.5.2.5.6

Rolled products thickness, mm	Depending on the rolled products thickness the required temperature values $T_{d\ (NTD)}$, $T_{d\ (Tkb)}$, $T_{d\ (DWTT)}$ for the steel marked with upper index «Ice»		
	$T_{d\ (NTD)}$, °C	$T_{d\ (Tkb)}$, °C	$T_{d\ (DWTT)}$, °C
From 25 up to 30 incl.	*NDT* + 15	T_{kb}	*DWTT*
Over 30 up to 40 incl.	*NDT* + 20	T_{kb} - 15	*DWTT* -10
Over 40 up to 50 incl.	*NDT* + 25	T_{kb} - 25	**-**
Over 50 up to 60 incl.	*NDT* + 30	T_{kb} - 15	**-**
Over 60	*NDT* + 30	[1]	**-**

[1] Provided in addition to: $T_{kb} < 0,5\ T_{d\ (NTD)} + 15$
Note: Additional condition means $T_{kb} \leq -5$°C for **Ice40** and $T_{kb} \leq -15$°C для **Ice60**

For the metal thickness of 40 mm, in case the difference between *NDT* and T_{kb} temperatures is over 50°C, to control discontinuity of the material properties on resistance to brittle fracture, NDT specimens cut out from the mid-thickness of rolled products may be additionally tested in accordance with 2.2.10.3. NDT obtained during the test may be considered as a replacement of temperature $T_{d\ (Tk)}$.

It is possible to determine $T_{d\ (b\text{-}d)}$ based on one or two ductile-brittle transition temperatures determined $T_{d\ (NTD)}$, $T_{d\ (Tkb)}$, $T_{d\ (DWTT)}$.

3.5.2.5.7 In all types of tests the greatest value shall be accepted as the minimum operating material temperature T_d, up to which the steel in question may be used for all the structural members without limitations:

d = max($T_{d\ (CTODbm)}$, $T_{d\ (CTODHAZ)}$, $T_{d\ (b\text{-}d)}$.

3.5.2.6 Manufacture and supply of steel rolled products designed for operation at design temperatures below -30°C having thickness between 6 and 15 mm inclusive, is not allowed without mechanical tests. Mechanical tests shall mandatory include impact bending tests (*KV*) at a temperature not exceeding T_d on test specimens in compliance with **2.2.3.1**.

For the rolled products with strength class of 460 MPa and above, additional tests results shall be submitted to the Register. Failing that, said tests shall be conducted:

determining temperature *DWTT* of a fibrous component in the fracture of a full-thickness specimen and minimum temperature T_d (for rolled products of 6 mm and over);

determining minimum temperature T_d by T_{kb} method (for rolled products of 10 mm and over);

determining *CTOD* for *J* – integral at the calculated temperature (for rolled products of 6 mm or more), at $CTOD \geq 0{,}08$ mm;

determination of weldability (extension across the seam, bending, impact bending along the zones of the welded joint), heat generation during welding of a butt test is subject to separate agreement with the Register.

Besides, if the above special tests were not performed, special standards shall be spec-ified for the impact energy of the base metal and welded joints (refer to Table 3.5.2.6) at a temperature not exceeding T_d.

The impact energy may be reduced to 70 % of the required value for one of the three test specimens.

For the rolled products with thickness of less than 10 mm, the required impact energy shall be determined by Formula (2.2.3.1).

Table 3.5.2.6 **The impact energy standards for the flat rolled products and welded joints with thickness of up to 15 mm at a temperature not exceeding T_d for the arctic ships and icebreakers in absence of the special tests**

Minimum yield stress in MPa	**Minimum average value for three test pieces**	
	rolled product thickness of 10 mm	rolled product thickness above 10 to 15 mm inclusive
460	46*L*, 31*T*	60*L*, 40*T*
500	50*L*, 33*T*	68*L*, 45*T*
550	55*L*, 37*T*	83*L*, 55*T*
620	70*L*, 46*T*	98*L*, 65*T*
690	86*L*, 57*T*	120*L*, 80*T*

3.5.3 Steel forgings.

3.5.3.1 Хімічний склад.

Chemical composition. The chemical composition of steel for forgings being part of hull structures is specified in the Registerrecognized standards and/or approved specification and shall provide for the cold resistance characteristics as required **3.7.2**. The content of sulfur and phosphorus in carbon and carbon-manganese steel should be not more than 0.015% and 0.030%, respectively, and in alloy steel - not more than 0.015% of each element.

3.5.3.2 The mechanical properties of forged steel shall meet the requirements of **3.7.3**.

The required impact energy value during impact testing at the minimum design temperature T_d is specified in the Registerrecognized standards and/or an approved specification, but shall be as follows:

not less than 27 J at the yield stress of steel less than 400 MPa;

not less than 41 J at the yield stress of steel from 400 to 690 MPa. The percentage of fibrous component in the fracture of a specimen determined after impact testing shall be not less than 50 %.

To approve steel for essential forgings used at -30°C and below, resistance to brittle fracture may be confirmed either by testing according to the NTD procedure (refer to **2.2.10.3**) or by other test methods agreed with the Register, e.g. crack resistance tests.

The requirements for forgings for cargo-handling gear are set forth in Section 3 of the Rules for the Cargo Handling Gear of Sea-Going Ships.

3.5.4 Steel castings.

3.5.4.1 Chemical composition.

The chemical composition of steel for the castings being part of hull structures is specified in the Register-recognized standards and/or approved specification and shall provide for the cold resistance characteristics as required. The sulphur and phosphorus content in alloy steel shall not exceed 0,015 % for each member.

3.5.4.2 Mechanical properties.

The mechanical properties of cast steel shall meet the requirements of 3.8.3. The required impact energy value during impact testing at the design temperature is specified by standards or technical requirements, but shall be as follows:

not less than 27 J at the yield stress of steel less than 400 MPa;

not less than 41 J at the yield stress of steel from 400 to 690 MPa.

The percentage of fibrous component in the fracture of a specimen determined after impact testing shall be not less than 50 %. To approve steel for essential castings used at -30°C and below, resistance to brittle fracture may be confirmed either by testing according to the NTD procedure (refer to **2.2.10.3**) or by other test methods agreed with the Register, e.g. crack resistance tests.

The requirements for castings for cargo-handling gear are set forth in Section **3** of the Rules for the

Cargo Handling Gear of Sea-Going Ships.

3.5.5 Welding.

3.5.5.1 Technological requirements for the processes of welded structures manufacture, welded joints testing and for welding consumables shall be in compliance with Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships, and with the additional requirements and restrictions of this Section.

3.5.5.2 The grades of welding consumables for welding stuctures of normal, higher and high strength steel are chosen in compliance with **2.4.5**, Part XIII "Welding" of the Rules for the Classification, Construction and Equipment of MODU/FOP.

3.5.5.3 The welding consumables used for the manufacture of hull structures relating to structural member categories II and III for thicknesses over 30 mm may be tested to determine the crack resistance parameter CTOD. The tests may be carried out at the initial issue of a Certificate of Approval for Welding Consumables or at the stage of welding procedures approval by the Register.

3.5.5.4 Where requirements are imposed upon the crack resistance parameter CTOD of weld metal, its average values, in mm, at a design temperature shall be not less than those specified in Table 3.5.5.4.

Table 3.5.5.4

Thickness, not more than, mm	**Grade of welding consumable**						
	Requirements for CTOD value for weld metal, mm						
	Y36 i Y40	Y42	Y46	Y50	Y55	Y62	Y69
40	0,15	0,15	0,15	0,15	0,20	0,20	0,20
50	0,15	0,15	0,15	0,20	0,20	0,20	0,25
70	0,15	0,20	0,20	0,20	0,25	0,25	0,30

Three correct tests, as a minimum, shall be carried out with the minimum values being not less than 50 % of the required ones.

The tests are carried out in compliance with the requirements of Section 2, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP according to the Register-agreed programs.

3.6 STEEL FOR CHAIN CABLES AND ACCESSORIES

3.6.1 General.

3.6.1.1 The present requirements apply to steel rolled products, forgings and castings used for manufacture of chain cables and accessories. Steel forgings shall generally meet the requirements of **3.7** and steel castings — the requirements of **3.8**, unless otherwise stated.

3.6.1.2 All materials used for the manufacture of chain cables and accessories shall be supplied by the manufacturers recognized in accordance with **1.3.1.4**. Grade 1 rolled products may be used for the manufacture of chain cables with the Manufacturer's Certificates.

3.6.1.3 The manufacturer shall submit the specification for material to the Register for approval.

Stated in the specification shall be the melting and deoxidation procedure, specified chemical composition and mechanical properties, and terms of rolled products' acceptance and delivery as well.

Unless stated otherwise, melting and deoxidation procedures, chemical composition and condition of rolled products' delivery that do not fully comply with the requirements of this Chapter may be applied in accordance with the standards and specifications of the works as well as the national and international standards.

3.6.2 Chemical composition.

3.6.2.1 The chemical composition of steel is determined by ladle analisis.

The chemical composition of rolled steel bars, based on ladle analysis for grades 1 and 2 chain cables shall comply with Table 3.6.2.1.

3.6.2.2 For chain cables of grades 3, R3, R3S and R4 the chemical composition of steel shall comply with the specification agreed with the manufacturer of a chain cable and approved by the Register.

In addition the steel for chain cables of grade R4 shall contain not less than 0,2 % of molybdenum.

3.6.2.3 The rolled bars shall be made of killed steel, and the steel for chain cables of grades 2, 3, R3, R3S and R4 shall be deoxidized and fine grain treated.

Table 3.6.2.1 **Chemical composition of rolled steel bars**

Chain cable grade	**Content of elements**					
	C, max	Si	Mn	P	S	Al total[1], min
				max		
1	0,20	0,15–0,35	min 0,40	0,040	0,040	–
2[2]	0,24	0,15–0,55	max 1,60	0,035	0,035	0,020

[1] Aluminium may be replaced partly by other fine graining elements.
[2] Additional alloying elements may be used on the basis of the works' manufacturing experience or a standard/specification.

3.6.2.4 The chemical composition of forgings and castings shall be in accordance with the specification approved by the Register and be specified by the manufacturer for each heat.

3.6.3 Mechanical properties.

The mechanical properties of steel for chain cables and accessories shall ensure the properties according to the requirements of Table 3.6.3.

3.6.4 Condition of supply.

3.6.4.1 Rolled bars and round section forgings, unless otherwise stated, are supplied in as-rolled condition.

The finished forgings and castings may be supplied after heat treatment appropriate for each chain cable grade as specified in Table 7.1.3.4. Forgings and castings may be subjected to normalizing, normalizing and tempering, hardening and tempering. The type of heat treatment shall conform to the specification approved by the Register.

Table 3.6.3. **Mechanical properties of the chain material**

Chain cable grade	**Yield stress R_{eH}[3], MPa, min**	**Tensile strength R_m[3], MPa**	**Elongation A_5, %**	**Reduction in area Z[4], %**	**Impact test [1,2] KV**		
			min		Test temperature °C	Base metal	Weld joint
						Impact energy, min, J	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	–	370- 490	25	–	–	–	–
2	295	490–690	22	–	0	27	–
3	410	min 690	17	40	0 (–20)	60 (35)	–
R3	410	min 690	17	50	0 (–20)	60 (40)	50 (30)
R3S	490	min 770	15	50	0 (–20)	65 (45)	53 (33)
R4	580	min 860	12	50	–20	50	36

[1] For chain cables of grades R3, R3S and R4 ReH/Rm40,92.
[2] For cast steel of grades R3, R3S Z440%, for steel of grade R4 – Z435%.
[3] For chain cables of grades R3, R3S and R4 $R_{eH}/R_m \le 0{,}92$.
[4] For cast steel of grades R3 and R3S $Z \le 40\%$, for steel of grade R4 — $Z \le 35\%$.
$Z/Z' \ge 85$, where Z and Z' are the sample reduction in area under tension before and after heating, respectively.

3.6.4.2 When the rolled products manufacturer is recognized, the chain cables of grades 3, R3, R3S and R4 shall (and chain cables of grades 1 and 2 may optionally) be subject to control testing of material after heat treatment similar to the one of the chain cable manufacturer.

3.6.5 Mechanical tests.

3.6.5.1 The rolled bars are submitted for testing in batches. A batch not more than 50 t in mass shall comprise bars of the same cast and supply condition with a tolerance of diameter within 4 mm.

3.6.5.2 From each batch of rolled bars, a sample is taken, out of which a tensile test specimen and a set of test specimens for impact testing (*KV*) for chain cables of grades 2, 3, R3, R3S and R4 are machined.

Specimens shall be taken from the sample in the longitudinal direction according to Fig. 3.6.5.2.

The tests shall be carried out in accordance with the requirements of **2.2**. Prior to the tests, the samples shall be heat-treated following the procedures corresponding to the heat treatment of finished chain cables in accordance with **7.1.3.4**. The method and regime of the heat treatment shall be indicated by the chain cable manufacturer.

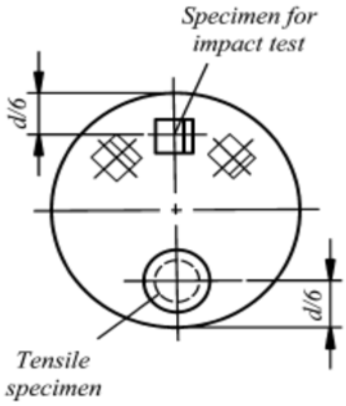


Fig. 3.6.5.2

3.6.5.3 For chain cables of grades R3S and R4, tests of steel susceptibility to hydrogen embrittlement (reduction of ductility margin) shall be performed. For this purpose, two samples are taken from each cast:

in the case of continuous casting - from metal corresponding to the beginning and the end of the cast section;

in the case of ingot making - from metal corresponding to any two ingots.

Tensile test specimens shall be cut from each sample representing the central part of rolled product (the rolled steel products shall be heat treated in the same conditions and shall preferably belong to the same furnace charge). Two tensile test specimens taken from a heat of steel shall be 20 mm in diameter (it is permitted to use specimens 14 mm in diameter).

One of the two specimens shall be tested not less than 3 h after production (for a specimen with a diameter of 14 mm, the time is 1,5 h). The other specimen shall be tested after being conditioned for 4 h at 250°C (for a specimen with a diameter of 14 mm, the time is 2 h).

Throughout the test up to the fracture of the specimen, the strain rate (change of elongation in fractions of gage length of the specimen) shall be less than 0,0003 s^{-1} (which amounts to approximately 10 min for a specimen of 20 mm in diameter). Testing is carried out to determine the tensile strength, elongation and reduction in area. Test results shall comply with Table 3.6.3 (refer to Footnote 4 at the bottom of the Table).

When the obtained value $Z/Z' < 0,85$, the metal presented for testing may be degassed, after which all the above testing shall be performed.

3.6.5.4 Mechanical tests results shall meet the requirements of Table 3.6.3.

Where the rest results are unsatisfactory, retests in accordance with **1.3.4.2** shall be carried out. In this case, the reheat treatment is allowed and the new tests may be performed on the metal taken from the material initially submitted for testing.

If the retest results are positive, those previously obtained may be disregarded.

3.6.5.5 Recognizing the manufacturer of steel for chain cables of grades R3, R3S and R4 the steel resistance to strain ageing, temper brittleness and hydrogen embrittlement shall be confirmed by following procedures approved by the Register.

3.6.6 Inspection.

3.6.6.1 The tolerances for rolled bars shall be within the limits specified in Table 3.6.6.1.

3.6.6.2 Rolled bars shall be free from shrinkage holes, cracks, flakes (hairlines), folds, laps and scale and also other internal and surface defects that might impair proper workability and use.

The longitudinal discontinuities, not more than 1 % of rolled bars diameter in depth, may be repaired by grinding with smooth transition to the surface.

Table 3.6.6.1

Nominal diameter, mm	**Tolerance on diameter, mm**	**Tolerance on roundness, ($d_{max} - d_{min}$), mm**
<25	-0 + 1,0	0,6
25—35	-0 + 1,2	0,8
36—50	-0 + 1,6	1,1
51 —80	-0 + 2,0	1,5
81 — 100	-0 + 2,6	1,95
101 — 120	-0 + 3,0	2,25
121 — 160	-0 + 4,0	3,00

3.6.7 Non-destructive testing.

Rolled bars for chain cables of grades R3, R3S and R4 shall be subjected to 100 % ultrasonic testing and also to magnetic particle or eddy-current testing according to standards approved by the Register.

The scope of non-destructive testing may be reduced if the quality stability of rolled bars manufacturing is confirmed.

3.6.8 Marking and documentation.

Generally, the marking shall be made in accordance with the requirements of **1.4**.

The marking content shall allow the identification of the supplied product and may be prescribed by the manufacturer.

In this case, as a minimum, the marking shall indicate the grade and heat the rolled products belong to. Round bars up to and including 40 mm in diameter may be supplied in bundles with the marking allowed to be made on labels (refer to **1.4**).

Each batch of steel for grade 2, 3, R3, R3S and R4 cable chains shall be accompanied by the Register certificate or the Manufacturer's Certificate witnessed by the Register representative. The Register and Manufacturer's Certificate forms shall correspond.

The Manufacturer's Certificate shall contain the following data:

document number;

order number; hull number of ship or floating facility;

rolled products quantity and dimensions, batch weight;

specification for steel, and chain cable grade;

heat number;

manufacturing methods;

chemical composition;

procedure for sample heat treatment.

If needed, the test reports may be attached to the Certificate.

3.7 STEEL FORGINGS

3.7.1 General.

3.7.1.1 The present requirements are applicable to steel forgings intended for hull and machinery applications such as rudder stocks, pintles, propeller and intermediate shafts, crankshafts, camshafts, connecting rods, piston rods, and other parts of machinery and gearing set forth in other parts of the Rules and having respective references to this Chapter.

Where relevant, these requirements are also applicable to material for forging stock and to rolled bars intended to be machined into components of simple shape.

3.7.1.2 The requirements of this Chapter are applicable only to steel forgings (or rolled steel when used instead of steel forgings as specified in 3.7.1.1) where the designation is determined proceeding from the properties at ambient temperature.

Additional requirements for forgings intended to operate at low or high temperatures are determined on a case-by-case basis.

3.7.1.3 Alternatively to the manufacturing of steel forgings (or rolled steel when used instead of steel forgings as specified in **3.7.1.1**), forgings, which comply with national or proprietary specifications, may be accepted by the Register. In this case, according to the procedure specified in **1.3.1.2**, the equivalence of these alternative requirements or their justification for the given manufacture and/or application shall be confirmed to the Register.

3.7.1.4 Steel forgings (or rolled steel when used instead of steel forgings as specified in **3.7.1.1**) shall be made by the manufacturer recognized by the Register in compliance with **1.3.1.2**. The steel used in the manufacture of the forgings shall be made by the process approved by the Register.

Adequate top and bottom discards (of a rolled blank) shall be made to ensure freedom from piping and harmful segregations in the finished forgings.

3.7.1.5 The plastic deformation (reduction ratio) shall be such as to ensure soundness, uniformity of structure and satisfactory mechanical properties after heat treatment.

The reduction ratio shall be calculated with reference to the average cross-sectional area of the cast material.

Where the cast material is initially upset, the plastic deformation reached during this operation may be considered.

Unless otherwise stipulated or agreed the total reduction ratio shall be at least:

for forgings made from ingot or from forged bloom or billet, using continuous casting plant — 3:1 where $L>D$ and1, 5:1 where $L\leq D$;

for forgings made from rolled products, 4:1 where$L>D$ and 2:1 where $L\leq D$;

for forgings made by upsetting, the length after upsetting shall be not more than one-third of the length before upsetting or, in the case of an initial forging reduction of at least 1,5:1, not more than one-half of the length before upsetting;

for rolled bars, 6:1

where L and D are the length and diameter respectively of the part of the forging or its part.

3.7.1.6 For crankshafts, where grain flow is required in the most favourable direction in regard to the mode of stressing in service, the pressure shaping process shall be subject to agreement by the Register.

3.7.1.7 The shaping of forgings or rolled slabs and billets by flame cutting, scarfing or arc-air gouging shall be carried out before the final heat treatment.

Preheating shall be employed when necessitated by the composition and/or thickness of the steel. For certain components, subsequent machining of all flame cut surfaces may be required.

3.7.1.8 When two or more forgings are joined by welding to form a composite component, the chemical composition and welding procedure shall be agreed by the Register; welding joints' procedure qualification tests may be required.

3.7.2 Chemical composition.

3.7.2.1 The chemical composition of steel for forgings shall be appropriate for the type of steel and the required mechanical and special properties of the forgings being manufactured.

The forgings shall be made from killed steel.

3.7.2.2 The chemical composition of each heat shall be determined by the manufacturer on a sample taken preferably during the pouring of the heat.

When multiple heats are tapped into a common ladle, the ladle analysis shall apply.

3.7.2.3 The chemical composition shall comply with the requirements of Table 3.7.2.3-1 (for hull steel forgings) and Table 3.7.2.3-2 (for machinery steel forgings) or with the requirements of the specification agreed by the Register.

3.7.2.4 If not otherwise stated, grain refining elements such as aluminium, niobium or vanadium may be added at the discretion of the manufacturer. The content of such elements shall be reported in the results of the chemical analysis.

3.7.2.5 Elements designated as residual elements shall not be contained in steel in great quantity. The content of such elements shall be reported in the results of the chemical analysis.

Table 3.7.2.3-1 [1]

Steel type	**C**	**Si**	**Mn**	**P**	**S**	**Cr**	**Mo**	**Ni**	**Cu**[4]	**Total residuals**
Carbon, carbonmanganese	0,23[2, 3]	0,45	0,3-1,5	0,035	0,035	0,30[4]	0,15[4]	0,40[4]	0,30	0,85
Alloy [5]	—	0,45	—	0,035	0,035	—	—	—	0,30	—

[1] Composition in percentage mass by mass maximum unless shown as a range.

[2] The carbon content may be increased above this level, provided that the carbon equivalent (Ceq) is not more than 0.41 %, calculated using the following formula:

$$C_{eq}\,(\%) = C + Mn6 + (Cr + Mo + V) / 5 + (Ni+ V) / 15.$$

[3] The carbon content of carbon and carbon-manganese steel forgings not intended for welded structures may be 0.65 % maximum.

[4] Element is considered as residual element.

[5] The content of C, Mn, Cr, Mo, Ni and the total content of residual elements shall be indicated in the specification to be submitted for agreement.

Note: Shaft and rudder stocks forgings shall be of weldable steel.

Table 3.7.2.3-2 [1]

Type of steel	C	Si	Mn	P	S	Cr	Mo	Ni	Cu [4]	Total residuals
Carbon, carbonmanganese	0,65[2]	0,45	0,3-1,5	0,035	0,035	0,30[3]	0,15[3]	0,40[3]	0,30	0,85
Alloy [4]	0,45	0,45	0,3-1,0	0,035	0,035	Min 0,40[5]	Min 0,15[5]	Min 0,40[5]	0,30	—

[1] Composition in percentage mass by mass maximum unless shown as a range or minimum value indicated.
[2] The carbon content of forgings intended for welded structures shall be 0.23 maximum.
The carbon content may be increased above the level given, provided that the carbon equivalent (Ceq) is not more than 0.41 %, calculated using the formula C_{eq} (%) = C + Mn/6 + (Cr+ Mo + V) / 5 + (Ni + V) / 15.
[3] Element is considered as residual element.
[4] Where alloy steel is intended for welded structures, the proposed chemical composition shall be indicated in the specification to be submitted for agreement.
[5] The content of one or more of the specified elements shall comply with the minimum content.

3.7.3 Mechanical properties.

3.7.3.1 Tables 3.7.3.1-1 and 3.7.3.1-2 give the minimum requirements of the Register for yield stress, elongation, reduction in area and impact test energy values corresponding to the different strength levels.

Where it is proposed to use a steel with a specified minimum tensile strength intermediate to those given, corresponding minimum values required by the Register for the other properties specified in the above tables may be obtained by interpolation.

Forgings may be used where their properties are those established in the relevant standards recognized by the Register.

Table 3.7.3.1-1 **Mechanical properties of steel forgings intended for ship construction**

Type of steel	Tensile strength R_m, min, MPa	Yield stress R_e, min, MPa	Elongation A_5, min, %		Reduction in area Z, min, %	
			Longitudinal	Tangential	Longitudinal	Tangential
Crosswise	400	200	26	19	50	35
	440	220	24	18	50	35
	480	240	22	16	45	30
	520	260	21	15	45	30
	560	280	20	14	40	27
	600	300	18	13	40	27
Alloy	550	350	20	14	50	35
	600	400	18	13	50	35
	650	450	17	12	50	35

Note: Note: The tensile strength values obtained at tensile testing shall not exceed the specified values by more than:
120 MPa, where $R_m < 600$ MPa;
150 MPa, where $R_m \geq 600$ MPa.

Table 3.7.3.1-2 **Mechanical properties for hull steel forgings** [1]

Steel type	Tensile strength[2] R_m, min, MPa	Yield stress R_e, min, MPa	Elongation A_5, min, %		Reduction in area Z, min, %		Brinell hardness[3] HB
			Longitudinal	Tangential	Longitudinal	Tangential	
Carbon, carbonmanganese	400	200	26	19	50	35	110—150
	440	220	24	18	50	35	125—160
	480	240	22	16	45	30	135—175
	520	260	21	15	45	30	150—185
	560	280	20	14	40	27	160—200
	600	300	18	13	40	27	175—215
	640	320	17	12	40	27	185 —230
	680	340	16	12	35	24	200—240
	720	360	15	11	35	24	210—250
	760	380	14	10	35	24	225—265
Alloy	600	360	18	14	50	35	175—215
	700	420	16	12	45	30	205—245
	800	480	14	10	40	27	235—275
	900	630	13	9	40	27	260—320
	1000	700	12	8	35	24	290—365
	1100	770	11	7	35	24	320—385

[1] 1 For propeller shaft forgings, except non-ice ships and ships with ice category mark **Ice1** and **Ice2**, impact tests for all steel grades shall be carried out at -10°C and the minimum required average impact energy value KV of 27 J (longitudinal specimen). No more than for one of three specimens the result may be by 30 % below than required.

[2] The following ranges for tensile strength may be additionally specified: the tensile strength values obtained at tensile testing shall not exceed the following:

150 MPa for the specified R_m < 900 MPa;

200 MPa for the specified $R_m \geq$ 900 MPa.

[3] The hardness values are given for information purposes only.

3.7.3.2 Hardness tests may be required by the Register on the following:

.1 gear forgings after completion of heat treatment and prior to machining the gear teeth.

The hardness shall be determined at four positions equally spaced around the circumference of the surface where teeth will subsequently be cut.

Where the finished diameter of the toothed portion exceeds 2,5 m, the above number of test positions shall be increased to eight.

Where the width of a gear wheel rim forging exceeds 1,25 m, the hardness shall be determined at eight positions at each end of the forging.

.2 small crankshaft and gear forgings, which have been batch tested.

In such cases at least one hardness test shall be carried out on each forging.

The results of hardness tests shall be reported to the representative of the Register.

Corresponding Brinell hardness values are given in Table 3.7.3.1-2 for information purposes.

Hardness tests may also be required on forgings, which have been induction hardened, nitrided or carburized. For gear forgings these tests shall be carried out on the teeth after, where applicable, they have been ground to the finished profile. The results of such tests shall comply with the documentation agreed and recognized by the Register (refer to **3.7.4.6**).

3.7.3.3 Where the test results are unsatisfactory re-testing shall be conducted in accordance with **1.3.2.4**.

3.7.4 Heat treatment (including surface hardening and straightening).

3.7.4.1 All the forgings shall be suitably heat treated to obtain the required mechanical properties and metal structure, and to refine the grain structure. The procedure of heat treatment shall be chosen by the manufacturer proceeding from the chemical composition of steel, the purpose and dimensions of the forging.

3.7.4.2 Except as provided in **3.7.5.7** and **3.7.5.8** forgings shall be supplied in one of the following conditions:

.1 carbon and carbon-manganese steels:

fully annealed;

normalized;

normalized and tempered;

quenched and tempered;

.2 alloy steels:

quenched and tempered.

The tempering temperature shall not be less than 550°C.

Where forgings for gearing are not intended for surface hardening, lower tempering temperature may be allowed.

3.7.4.3 Alloy steel forgings may be supplied in the normalized and tempered condition.

In each case the specifications for forgings shall be agreed by the Register and confirmed by the results of control tests when necessary.

3.7.4.4 Heat treatment shall be carried out in properly equipped furnaces, which have adequate means for temperature recording. The furnace shall provide the required quality of operation and proper level of control over the process regardless of forging dimensions.

In the case of very large forgings, or lack of the required equipment methods of heat treatment will be specially considered by the Register on a separate request.

3.7.4.5 If for any reasons a forging is subsequently heated for further hot working, the forging shall be reheat treated.

3.7.4.6 Where it is intended to surface harden forgings, the proposed procedure and specification shall be agreed by the Register.

The results of tests to verify the uniformity and depth of surface layer shall be submitted to the Register.

3.7.4.7 Where induction hardening or nitriding shall be carried out, forgings shall be heat treated at an appropriate stage and condition suitable for this subsequent surface hardening.

3.7.4.8 Where carburizing shall be carried out, forgings shall be heat treated at an appropriate stage (generally either by full annealing or by normalizing and tempering) and condition providing the required level of mechanical properties and hardening.

3.7.4.9 If a forging is locally reheated or any straightening operation is performed after the final heat treatment, it shall be heat treated to relive the subsequent stress.

3.7.4.10 The forge shall maintain records of heat treatment identifying conditions, the furnace used, furnace charge, time of charging, temperatures and time of conditioning.

The records shall be presented to the Register on request.

3.7.5 Sampling.

3.7.5.1 The sample, sufficient for the required tests and for possible retest purposes, shall be provided with a cross-sectional area of not less than that part of the forging, which it represents.

This sample shall be integral with each forging except as provided in **3.7.6.1.10** and **3.7.6.1.13**. Where batch testing is permitted according to **3.7.6.1.13**, the sample may alternatively be a production part or separately forged.

Separately forged sample shall have dimensions not less than those of the forgings represented.

3.7.5.2 Generally, a tensile test specimen and, when required, a set of impact tests specimens shall be cut from a sample.

3.7.5.3 Test specimens shall normally be cut with their axes either mainly parallel (longitudinal test) or mainly tangential (tangential test) to the principal axial direction of each product.

Unless otherwise agreed, longitudinal test specimens shall be cut the following way:

.1 for thickness or diameter up to maximum 50 mm, the axis shall be at the mid-thickness or the center of the cross section;

.2 for thickness or diameter greater than 50 mm, the axis shall be at one-quarter thickness ($^1/_4$ of the diameter) or 80 mm, whichever is less, below any heat-treated surface.

3.7.6 Scope of testing.

3.7.6.1 Forgings shall be submitted for testing individually or in batches.

Except as provided in **3.7.6.13** the number and direction of tests shall correspond to the listed below:

.1 *hull forgings (such as rudder stocks, pintles, etc) and general machinery components (such as shafting, connecting rods, etc.):*

one sample shall be taken from the end of each forging in a longitudinal direction except that, at the discretion of the manufacturer, the alternative directions or positions as shown in Fig. 3.7.6.1.1-1, 3.7.6.1.1-2 and 3.7.6.1.1-3 may be used;

where a forging exceeds both 4 t in mass and 3 m in length, one sample shall be taken from each end. These limits refer to the "as forged" mass and length but excluding the sample material;

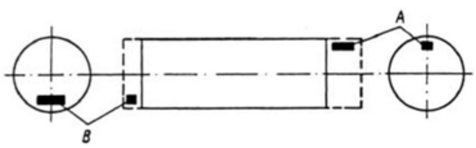


Fig.3.7.6.1.1-1

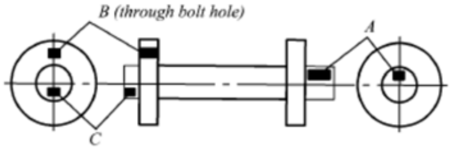


Fig.3.7.6.1.1-2

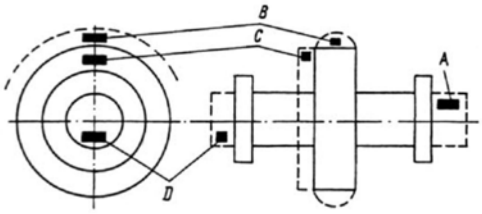


Fig.3.7.6.1.1-3

.2 *pinion forgings:*

where the finished machined diameter of the toothed portion exceeds 200 mm, one sample shall be taken from each forging in a tangential direction adjacent to the toothed portion according to Fig. 3.7.6.1.2 (position *B*).

Where the dimensions preclude sampling from position *B*, sample in a tangential direction shall be taken according to Fig. 3.7.6.1.2 (position *C*);

if however, the journal diameter is 200 mm or less, the sample shall be taken in a longitudinal direction according to Fig. 3.7.6.1.2 (position *A*);

where the finished length of the toothed portion exceeds 1,25m, one sample shall be taken from each end;

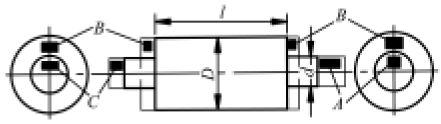


Fig. 3.7.6.1.2

.3 *small pinion forgings:*

where the diameter of the toothed portion is 200 mm or less, one sample shall be taken in a longitudinal direction according to Fig. 3.7.6.1.2 (position A);

.4 *gear wheel forgings:*

one sample shall be taken from each forging in a tangential direction according to Fig. 3.7.6.1.4 (position *A* or *B*);

.5 *gear wheel rim forgings (made by expanding):*

one sample shall be taken from each forging in a tangential direction according to Fig. 3.7.6.1.5 (position *A* and *B*);

where the finished diameter exceeds 2,5 m or the mass (as heat treated excluding test material) exceeds 3 tonnes, two samples shall be taken from diametrically opposite positions according to Fig. 3.7.6.1.5 (positions *A* and *B*).

The mechanical properties may as well be determined on longitudinal test specimens.

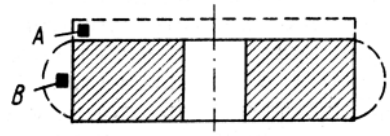


Fig.3.7.6.1.4

Рис. 3.7.6.1.3

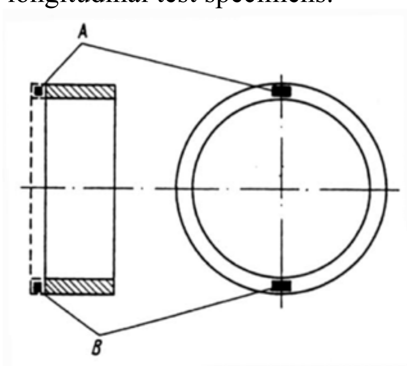


Fig.3.7.6.1.5

.6 *pinion sleeve forgings:*

one sample shall be taken from each forging in a tangential direction according to Fig. 3.7.6.1.6 (position *A* and *B*);

where the finished length exceeds 1,25 m, one sample shall be taken from each end;

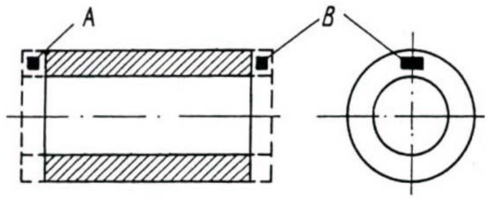


Fig.3.7.6.1.6

.7 *crankweb forgings:*

one sample shall be taken from each forging in a tangential direction;

.8 *solid-forged crankshafts:*

where the mass (as heat treated but excluding test material) exceeds 3 tonnes, one sample in a longitudinal direction shall be taken from each end according to Fig. 3.7.6.1.8 (positions *A* and *B*);

where, however, the crankthrows are formed by machining or flame cutting, the second sample shall be taken in a tangential direction from material removed from the crankthrow at the end opposite the driving shaft end (from coupling) according to (position *C*);

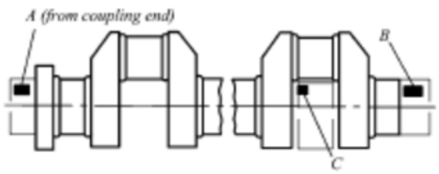


Fig.3.7.6.1.8

.9 *forgings with grain flow in the most favorable direction where the method of manufacture is subject to approval by the Register in accordance with* ***3.7.1.6****:*

the number and position of samples shall be agreed in the course of approval of respective procedure and recognition of the manufacturer;

.10 *when a forging is subsequently divided into a number of components:*

all of which are heat treated together in the same furnace charge, for test purposes this may be regarded as one forging and the number of tests required shall be related to the total length and mass of the original multiple forging;

.11 except for components, which shall be carburized, or for hollow forgings samples shall not be cut from a forging until all heat treatment has been completed;

.12 *when forgings shall be carburized,*

the sample size shall provide for both preliminary tests (after the forge) and for final tests (after completion of carburizing). For this purpose duplicate sample shall be taken from positions as detailed in **3.7.6.1**, except that irrespective of the dimensions or mass of the forging, tests are required from one position only and, in the case of forgings with integral journals, shall be cut in the longitudinal direction.

Samples shall be machined to a diameter of *D*/4 or 60 mm, whichever is less, where *D* is the finished diameter of the toothed portion.

For preliminary tests (after the forge) the samples shall be given a blank carburizing and heat treatment cycle simulating that which subsequently will be applied to the forging.

For final acceptance tests, the rest of samples shall be blank-carburized and heat-treated along with the forgings, which they represent.

At the discretion of the forge or gear manufacturer, test samples of larger cross section may either be carburized or blank-carburized, but these shall be machined to the required diameter prior to the final quenching and tempering heat treatment.

Alternative procedures for testing the forgings to be carburized are subject to the approval the Register as part of the submitted documentation.

.13 normalized forgings with a mass up to 1000 kg each and quenched and tempered forgings with mass up to 500 kg each may be batch tested.

A batch shall consist of forgings of similar shape and dimensions, made from the same heat of steel, heat treated in the same furnace charge and with a total mass not exceeding 6 t for normalized forgings and 3 t for quenched and tempered forgings, respectively;

.14 a batch testing procedure may also be used for hot rolled bars. Batch quantity is determined proceeding from the following:

.14.1 material from the same rolled ingot or bloom provided that these are all heat treated in the same furnace charge;

.14.2 bars of the same diameter and heat, heat-treated in the same furnace charge and with a total mass not exceeding 2,5 t;

.15 the preparation of test specimens and testing procedures shall comply with the relevant requirements of Section 2.

Unless otherwise agreed, all tests shall be carried out in the presence of the Register representative.

3.7.7 Inspection.

3.7.7.1 All forgings shall be presented to the Register representative for visual testing including, where necessary, the examination of internal surfaces and bores. Unless otherwise agreed, the verification of dimensions is the responsibility of the Manufacturer.

orgings shall not have defects that prevent their intended use.

3.7.7.2 When required by the relevant parts of the Rules or by the Register approved technical documentation, the forgings, including forged composite components, which shall be welded (refer to **3.7.1.8**), appropriate non-destructive testing shall also be carried out. The results shall be reported to the Register representative and included in a relevant quality document of the manufacturer on a forging or batch.

The scope of testing and acceptance criteria shall be agreed with the Register.

3.7.7.3 When surface hardening of forgings is required (refer to 3.7.4.6), additional samples may be selected at the time of inspection.

These samples shall be subsequently sectioned in order to determine the hardness, shape, area and depth of the locally hardened zone and which shall comply with the requirements of the Register approved documentation.

3.7.7.4 In the event of any forging proving defective in accordance with the Rules or Register approved documentation during subsequent machining or testing, it shall be rejected notwithstanding prior survey results.

3.7.7.5 It is permitted to remove surface defects by grinding or chipping and grinding within mechanical allowances. The resulting grooves shall have a bottom radius of approximately three times the groove depth. Sharp contours are not permitted.

Complete elimination of defective material shall be verified by magnetic particle or penetrant testing.

3.7.7.6 Repair welding of forgings is defined by the forgings documentation approved by the Register.

Procedure and location of the repair, subsequent heat treatment and inspection methods and criteria shall, for each case, be entered into a separate document and approved by the Register.

3.7.7.7 The forging manufacturer shall maintain records of repairs and subsequent inspections, which results shall be shown in a drawing or sketch of the forging.

Respective information shall be submitted to the Register representative at the latter's request.

3.7.8 Identification and marking.

3.7.8.1 The manufacturer of forgings shall adopt a system of identification, which will enable all finished forgings, at the stage of being submitted to the Register, to be traced to the original cast, and the data pertinent to the process of a particular forging (batch) manufacture, which shall be recorded during the above process, including heat treatment and repair, shall be presented to the Register representative on request.

3.7.8.2 All forgings shall be clearly marked in a specified place and in a specified manner with the Register stamp or brand to include at least the following particulars:

manufacturer's name or trade mark;

identification number or other marking, which will enable the full history of the forging to be traced;

steel grade.

3.7.8.3 Where small forgings are manufactured in large numbers, modified arrangements for identification may be specially agreed by the Register.

3.7.8.4 The Manufacturer's Certificate to be submitted to the Register representative shall include the following particulars:

purchaser's name and order number;

steel grade and description of forgings;

identification number;
steel melting process, cast number and chemical composition as per the ladle analysis;
results of mechanical tests;
results of non-destructive testing, where applicable;
details of heat treatment, including temperature and time of conditioning.

3.8 STEEL CASTINGS

3.8.1 General.

3.8.1.1 Steel castings subject to survey by the Register, when produced in conformity with the relevant parts of the Rules, shall be manufactured and tested in accordance with the requirements stated below. 3.8.1.2 These requirements are applicable to carbon and carbon-manganese steel castings used in hull and ship machinery structures, (such as stern frames, rudder frames, crankshafts, turbine casings, bedplates, etc.), the purpose of which shall be established proceeding from their properties determined at room temperature.

3.8.1.3 The requirements for castings to be used for operation at at low or high temperature, as well as for alloy steel castings with special properties shall be defined by the product designer in accordance with the national/international standards and thereafter approved by the Register. The documents submitted to the Register for approval shall contain detailed information on the chemical composition, mechanical and special properties, heat treatment procedures and scope of testing the castings.

3.8.1.4 When two or more castings are joined by welding to form a composite item, the chemical composition of steel and the welding procedure are subject to approval by the Register.

3.8.1.5 The castings shall be manufactured at works recognized according to **1.3.1.4**, in conformity with the procedure approved by the Register.

Use of surface hardening in the production process shall be also agreed with the Register.

3.8.2 Chemical composition.

3.8.2.1 The chemical composition of a particular type of steel will be established proceeding from the mechanical and special properties required. The castings shall be made from killed steel.

3.8.2.2 For carbon and carbon-manganese steel castings the chemical composition of ladle samples shall comply with the requirements of Table 3.8.2.2 and/or of the documents (specifications, standards, etc.) agreed with the Register.

3.8.2.3 Unless otherwise required, suitable grain-refining elements may be used at the discretion of the manufacturer. The content of such elements shall be reported in the ladle analysis.

3.8.3 Mechanical properties.

3.8.3.1 The mechanical propertied of steel castings shall meet the requirements of Table 3.8.3.1 and/or of documentation approved by the Register.

Table 3.8.3.1 give minimum values of yield stress, elongation and reduction in area established depending on the required level of the tensile strength values for the steel castings.

***Table 3.8.2.2*. Chemical composition of carbon and carbon-manganese steel**

Steel grade	Application	C, max %	Si. max %	Mn, max %	S, max %	P, max %	Residual elements, max %				Total number of residual elements, max %
							Cu	Cr	Ni	Mo	
Carbon, carbon-manganese	Non-welded structures	0,40	0,60	0,50-1,60	0,040	0,040	0,30	0,30	0,40	0,15	0,80
	Welded structures	0,23	0,60	1,60	0,040	0,040	0,30	0,30	0,40	0,15	0,80

Table 3.8.3.1 **Mechanical properties of castings**

Tensile strength R_m, MPa min	Yield stress R_{eH} or $R_{p0,2}$, MPa	Elongation A_5, %	Reduction in area Z, %
400	200	25	40
440	220	22	30
480	240	20	27
520	260	18	25
560	300	15	20
600	320	13	20

Notes:
1 . Minimum yield stress value 250 MPa is allowed.
2. For intermediate tensile strength values, the minimum values of yield stress, elongation and reduction in area may be determined by linear interpolation.

3.8.3.2 Where tensile test results are unsatisfactory, retesting shall be conducted in compliance with the requirements of **3.8.6.4**.

3.8.4 Heat treatment.

3.8.4.1 To ensure the required structure and mechanical properties the castings shall undergo heat treatment. The procedure of heat treatment shall be chosen by the manufacturer proceeding from the chemical composition of steel, the purpose and shape of the castings.

The following conditions shall be observed:

tempering temperature shall not be less than 500°C;

the stress relief heat treatment of castings for components such as crankshafts and engine bedplates where dimensional stability and freedom from internal stresses are important, shall be carried out at a temperature of not less than 550°C, followed by furnace cooling to 300°C or lower;

if a casting is reheated or any straightening operation is performed after the final heat treatment, a subsequent stress relieving heat treatment may be required.

3.8.4.2 As a rule, the steel castings shall be supplied in the following condition:

completely annealed; after normalizing;

after normalizing and tempering;

after quenching and tempering.

All necessary data on the heat treatment process including procedures and appropriate instrument readings shall be submitted to the Register representative on his demand.

3.8.4.3 In case where steel casting after final heat treatment is subjected to local heating or to operations producing additional strain, heat treatment may be required to relieve residual stress.

3.8.5 Sampling.

3.8.5.1 Sampling may be effected directly from the casting or the test samples may be cast to it. They shall have a thickness not less than 30 mm.

The use of separately cast samples is permitted, in which case the dimensions of the sample shall correspond to the casting dimensions.

3.8.5.2 Where two or more samples shall be provided for a casting they shall be cast at locations as widely separated as possible.

3.8.5.3 The samples shall be heat treated together with the castings, which they represent.

3.8.5.4 The size of samples shall be such as to ensure the performance of tests including re-tests, if required. All samples shall be identified.

3.8.6 Scope of testing.

3.8.6.1 At least one sample shall be provided for each casting. Where one casting is made from several casts (without mixing) the number of samples shall be equal to the number of casts involved. The condition of **3.8.5.2** shall be met in this case.

Where the casting is of complex design or where the finished mass exceeds 10 t, at least two samples shall be provided.

3.8.6.2 A batch testing procedure may be adopted for castings. A batch shall consist of castings of approximately the same size and shape made from one cast and heat treated in the same furnace charge and having the total mass equal to or less than 1000 kg.

Such batch may be represented by one of the castings considered as a sample or by a separately cast sample, the dimensions of which shall correspond to the castings comprising the batch.

3.8.6.3 Unless otherwise specified, at least one tensile test specimen shall be taken from each sample.

Test specimens shall be prepared and the tests conducted in conformity with the requirements of Section **2**. Unless otherwise stated, tests shall be conducted in the presence of the Register representative.

3.8.6.4 Where the tensile tests yield unsatisfactory results the tests shall be repeated on two additional specimens preferably cut out from the same sample. In case the cutting out of additional specimens from the same sample is not possible, specimens may be cut out from other sample or casting.

Where the tests carried out on two additional specimens yield satisfactory results, the casting and the batch if represented by the casting shall be accepted.

Where the test result on at least one of two additional specimens is unsatisfactory, the casting submitted shall be rejected. However, the remaining semi-finished products of the batch may be accepted by the Register, provided that satisfactory test results are obtained on two more castings comprising the batch involved.

Where unsatisfactory test results are obtained on one of two additionally selected castings, the entire batch shall be rejected.

At the manufacturer's discretion, the batch or casting rejected may be submitted to re-tests on the same conditions after repeated heat treatment.

3.8.6.5 Where relevant requirements shall be found in other parts of the Rules, the castings shall be subjected to additional tests, such as pressure tests.

Where upon completion of all tests, owing to machining of the castings or as a result of any structural tests a defect is found, which interferes with the use of casting for its designated purpose, the batch shall be rejected irrespective of the availability of the relevant documents.

3.8.7 Inspection.

3.8.7.1 The castings submitted for inspection and control testing shall be cleaned, de-gated, free of risers and burrs, etc.

The castings shall be free from defects, which would be prejudicial to their proper application in service.

The responsibility for fulfilment of the requirements for dimensions of the castings shall be imposed on the manufacturer of the castings.

3.8.7.2 Where relevant requirements shall be found in other parts of the Rules or following the instructions of a Surveyor the castings shall undergo non-destructive testing.

testing procedure and the allowances for defects shall be in conformity with documentation approved by the Register.

3.8.7.3 Surface defects lying within machining allowances may be removed by machining.

3.8.7.4 Defects may be repaired by welding in accordance with **2.6.3**, Part XIV "Welding".

3.8.7.5 The size, number of defects accepted uncorrected as well as of defects to be corrected shall be established by the manufacturer and agreed with the customer.

The procedure of repair and subsequent inspection including, if necessary, welding is subject to agreement with the Register. All work shall be performed by the qualified personnel.

Repair welding shall be performed with the use of welding consumables recognized by the Register, which ensure properties of the deposited metal not inferior than those of the casting metal.

On completion of the repair welding, the castings shall be subjected to heat treatment to relieve residual stress at temperature not lower than 550°C. The type and procedure of heat treatment depends on the type and nature of repair work performed previously as well as on the material and size of the castings. Refusal to carry out the above postweld heat treatment is generally acceptable for small scopes of repair.

3.8.7.6 Upon completion of the repair welding of the castings, the magnetic particle or penetrant testing shall be carried out. Additional ultrasonic or radiographic testing may be required depending on the nature and size of surface defects detected.

Testing criteria are also subject to agreement with the Register.

3.8.7.7 All repair works and their results shall be documented and available for the Register representative.

3.8.8 Marking and documentation.

3.8.8.1 The manufacturer of the castings shall have an identification system, which enables to identify the casting with the ladle at a stage of submission to the Register, while upon the request of the Register representative, the manufacturer shall present the data, recorded in course of manufacture referred to the production process of a particular casting, or a batch, including thermal treatment and repair.

3.8.8.2 Every casting shall have clearly visible stamp or brand of the Register marked by the specified method and in specified location, and, at least, shall contain the following data:

name or designation of the manufacturer;

number or other marking, which enables to identify the presented material and the process of its production;

grade or mark of steel.

3.8.8.3 Where small castings are manufactured in large numbers the castings identification system may be agreed with the Register separately.

3.8.8.4 Manufacturer's Certificate, submitted to the Register representative, shall contain the following data:

name of purchaser and number of purchase order;

grade, (mark) of steel, type of casting;

identification number;

steel melting process, cast number and chemical composition as per the ladle analysis;

mechanical test results;

non-destructive testing results, if necessary;

heat treatment type, including temperature and time of conditioning.

3.9 SPHEROIDAL OR NODULAR GRAPHITE IRON CASTINGS

3.9.1 General.

3.9.1.1 As defined in the relevant parts of the Rules, all spheroidal or nodular graphite iron castings subject to survey by the Register shall be manufactured and tested in accordance with the requirements of the following paragraphs.

If the requirements of **3.1.2** are followed, castings may be manufactured according to international and national standards or works specifications.

3.9.1.2 These requirements are applicable to spheroidal or nodular graphite iron castings used in hull and ship machinery structures. The purpose of the castings shall be established proceeding from their properties at room temperature.

3.9.1.3 The requirements for castings intended for service at low or elevated temperatures shall be agreed as part of the submitted documentation. In this case, detailed information on the chemical composition, mechanical and special properties, heat treatment, methods and scope of testing the castings shall be submitted to the Register.

3.9.1.4 In the case of sustainable production of homogeneous castings, other methods and scope of tests may be allowed, provided that the stability of technological processes and the quality of castings are confirmed.

3.9.1.5 For removal of risers and for castings grinding the relevant metal machining methods may be used.

The methods exerting a thermal effect on casting quality are not allowed with the exception of their use as preliminary before machining.

3.9.1.6 When finished, castings shall be free of defects unfavourably effecting their use and shall be in full compliance with the approved documentation for delivery.

3.9.2 Chemical composition.

3.9.2.1 The chemical composition is left to the discretion of the manufacturer who shall ensure that it is suitable for obtaining the mechanical properties specified for the castings. Unless otherwise specified, the chemical composition of ladle analysis shall be reported.

3.9.3 Mechanical properties.

3.9.3.1 The mechanical properties of the castings shall conform to Table 3.9.3.1. While effecting the tensile test of the casting material the tensile strength and elongation shall be determined.

The minimum required tensile strength shall be stated in the agreed technical documentation for the casting, but in no case shall it exceed the limits detailed in Table 3.9.3.1.

Additional requirements of the relevant parts of the Rules are also to be complied with.

Where mechanical test results are unsatisfactory, retesting shall be conducted.

3.9.3.2 Where impact testing is required, the standards and type of specimen shall be approved by the Register.

3.9.3.3 The microstructure of the castings shall include not less than 90 % of spheroidal or nodular graphite. No flaked graphite is permitted.

3.9.4 Heat treatment.

3.9.4.1 The castings shall be supplied in either as the cast or heat treated condition.

The necessity of heat treatment and the relevant procedure shall be determined by the manufacturer on the basis of chemical composition, purpose and shape of the castings. The heat treatment for stress relieving shall follow the heat treatment for structure refining and to procede the machining.

Special quality castings having the tensile strength 350 and 400 MPa and the relevant necessary impact energy value shall undergo ferritizing.

Table 3.9.3.1. **Mechanical properties and structure of nodular graphite iron**

Tensile strength[1] R_m, MPa min		**Yield stress $R_{p0,2}$, MPa, min**	**Elongation A_5, %, min**	**Brinell hardness**	**Impact energy**		**Structure[4]**
					Test temperature, °C	KV[2], min, J	
Normal quality	370	230	17	120...180	—	—	Ferrite
	400	250	15	140...200	—	—	Ferrite
	500	320	7	170...240	—	—	Ferrite/Pearlite
	600	370	3	190...270	—	—	Ferrite/Pearlite
	700	420	2	230...300	—	—	Pearlite
	800	480	2	250...350	—	—	Pearlite structure or structure after tempering
Special quality	350	220	22 [3]	110...170	+20	17(14)	Ferrite
	450	250	18 [3]	140...200	+20	14(11)	Ferrite

[1] For intermediate tensile strength values the minimum values of elongation and upper yield stress may be determined by linear interpolation.
[2] When tests are carried out on three Charpy V-notch type test specimens, the impact energy mean value is given. It is allowed to lower the impact energy value for one of the three test specimens in comparison with data in Table, but not less than given in brackets.
[3] When tensile tests are carried out on test specimens out of cast-on samples, the ultimate values of elongation may be lowered by 2 % of the given value.
[4] Data for consideration.

3.9.4.2 Where it is proposed to locally harden the surfaces of a casting, full details of the proposed procedure and specification shall be submitted to the Register for consideration.

3.9.5 Добір проб.

3.9.5.1 The samples may be either cast-on or separately cast. The dimensions of the samples, when cast separately, shall be in accordance with Figs. 3.9.5.1-1, 3.9.5.1-2 and 3.9.5.1-3 (dimensions are given in mm); the sample length *l* shall be chosen proceeding from the type of the machine for tensile testing.

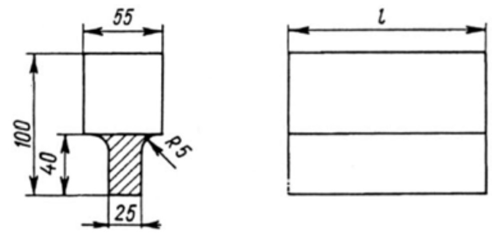


Fig. 3.9.5.1-1 Standard specimen and alternative specimens with dimensions:

Dimensions, mm			
Standard specimen*	**Alternative specimen****		
25	12	50	75
55	40	90	125
40	30	60	65
100	80	150	165

*- dimensions of the standard specimen specified in fig. 3.9.5
* *- dimensions alternative to the corresponding dimensions of the standard specimen.

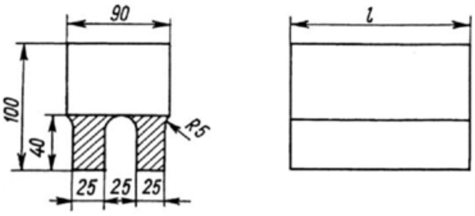


Fig. 3.9.5.1-2 Standard specimen

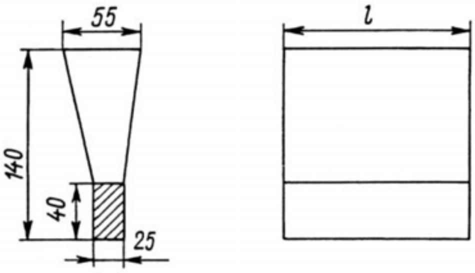


Рис. 3.9.5.1-3 Стандартний зразок і альтернативні зразки розмірами:

Dimensions, mm			
Standard specimen*	**Alternative specimen****		
25	12	50	75
55	40	90	125
40	30	50	65
140	135	150	175
*- dimensions of the standard specimen specified in fig. 3.9.5.1-3. * *- dimensions alternative to the corresponding dimensions of the standard specimen.			

The samples may have alternative dimensions or they may be taken directly from one of the castings forming the batch.

Thickness of the mould surrounding a standard specimen shall not be less than 40 mm, and for alternative samples, not less than 40, 60 and 80 mm respectively.

Where separately cast samples are used, they shall be cast in moulds made from the same type of material as used for the castings and shall not be stripped from the moulds until the sample metal temperature is below 500°C.

3.9.5.2 When castings are supplied in the heat treated condition, the samples shall be heat treated together with the castings, which they represent.

3.9.5.3 Samples for metallographic examination may conveniently be taken from the tensile test specimens, but separately cast samples may be prepared, provided that they are taken from the ladle towards the end of the casting period.

3.9.6 Scope of testing.

3.9.6.1 At least one sample shall be taken from each casting. If metal from several ladles is used for a casting, one sample shall be taken from each ladle.

3.9.6.2 A batch testing procedure may be adopted for castings with the fettled mass of 1 t or less. All castings in a batch shall be of similar type and dimensions, cast from the same ladle of treated metal. One separately cast sample shall be provided for each multiple of 2 t of fettled castings in the batch.

3.9.6.3 At least one tensile test specimen, shall be prepared from each sample according to **2.2.2.3** and, where required, a set of Charpy V-notch type test specimens for impact tests according to **2.2.3.1**.

3.9.6.4 Where the castings are subject to pressure testing for tightness, both the working and test pressure shall be stated in the technical documentation.

3.9.7 Inspection.

The castings shall be submitted for inspection and control testing in cleaned and de-gated condition, free from risers, etc.

The castings shall be free from defects, which would be prejudicial to their application in service. In general, repairing of defects by welding is not permitted. Subject to approval by the surveyor, surface imperfections may be removed by grinding. Where there is reason to suspect the soundness of the casting, non-destructive testing may be required. Crankshafts shall undergo magnetic particle testing and metallographic examination.

3.9.8 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of **3.8.8**.

3.10 GREY IRON CASTINGS

3.10.1 General.

3.10.1.1 All grey iron castings subject to survey by the Register, as defined in the relevant parts of the Rules, shall be manufactured and tested in accordance with the requirements of the following paragraphs.

3.10.1.2 The present requirements apply to grey iron castings used in hull and ship machinery structures.

3.10.1.3 Where castings of the same type are regularly produced in quantity, the manufacturer may adopt alternative procedures for, and scope of, testing, with the data verifying the continued efficiency of the manufacturing technique and the quality of castings submitted to the Register.

3.10.1.4 On condition that the requirements of **3.1.2** are followed, castings may be manufactured in compliance with national standards and works specifications.

3.10.1.5 Castings subject to survey by the Register and produced in large quantities shall be manufactured at works recognized by the Register as specified in **1.3.1.4**.

3.10.2 Chemical composition.

3.10.2.1 The chemical composition is left to the discretion of the manufacturer, who shall ensure that it is suitable for obtaining the mechanical properties specified for the castings.

Unless otherwise specified, the chemical composition of ladle analysis shall be reported.

3.10.3 Mechanical properties.

When carrying out the tensile test of the casting material (according to **2.2.2.4**) the tensile strength shall be determined. The specified minimum tensile strength shall be stated in the technical documentation for the casting, but in no case it shall be less than 200 MPa. Any additional requirements of the relevant parts of the Rules shall also be complied with.

Where tensile test results are unsatisfactory, retesting shall be conducted in compliance with the requirements of **1.3.4.2**.

3.10.4 Heat treatment.

3.10.4.1 Castings may be supplied in either as the cast or heat treated condition.

The necessity of heat treatment and the relevant procedure shall be determined by the manufacturer on the basis of chemical composition, purpose and shape of the castings.

The heat treatment for stress relieving shall follow the heat treatment for structure refining and to precede the machining.

3.10.5 Sampling.

3.10.5.1 Unless otherwise agreed between the manufacturer and the customer, cast samples shall have the form of cylindrical bars 30 mm in diameter and of a suitable lenght.

They shall be cast from the same ladle as the castings in moulds of the same type of material as the moulds for the castings and shall not be stripped from the moulds until the metal temperature is below 500°C.

If two or more samples are cast in one mould at the same time, the rod diameter shall not be less than 50 mm and they shall be located as specified in Fig. 3.10.5.1 (dimensions are given in mm).

The samples of alternative dimensions may be used, they may be cast-on or taken directly from the castings.

As a rule, cast-on samples may be used if the casting wall thickness is over 20 mm and its mass exceeds 200 kg. In addition, the sample type and location shall ensure roughly the same cooling conditions similar to the base casting cooling and are subject to the manufacturer's agreement with a customer.

3.10.5.2 Where castings are supplied in the heat treated condition, the samples shall be heat treated together with the castings, which they represent.

3.10.5.3 One tensile test specimen shall be prepared from each sample.

3.10.6 Scope of testing.

3.10.6.1 From each casting at least one sample shall be taken. Where metal from several ladles is used for a casting, one sample shall be taken from each ladle.

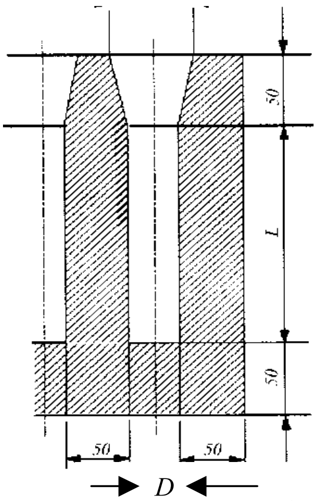


Fig.3.10.5.1

3.10.6.2 All castings in the batch shall be of similar type and dimensions, and cast from the same ladle of metal. As rule, the batch mass shall not exceed 2 t of fettled castings; separate castings with a mass equal to or over 2 t also form a batch.

At continuous casting of iron of the very same grade and in large quantities, the batch mass may be limited by the metal cast within two hours.

The batch volume and number of samples taken are subject to an agreement with the Register.

3.10.6.3 Where the castings are subject to pressure testing for tightness, both the working and test pressure shall be stated in the technical documentation.

3.10.7 Inspection.

The castings shall be submitted for inspection and control testing in cleaned and de-gated condition, free from risers, etc.

The castings shall be free from defects, which would be prejudicial to their proper application in service. In general, repairing of defects by welding is not permitted. At the discretion of the surveyor, small surface blemishes may be removed by local grinding. Where these is reason to suspect the soundness of the casting, non-destructive testing may be required.

3.10.8 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of **3.8.8**.

3.11 MALLEABLE CAST IRON

3.11.1 General.

Malleable cast iron may be used for the manufacture of parts for hull and ship machinery structures that are subject to survey by the Register and are intended to operate at a temperature not exceeding 300 8C and the working pressure not exceeding 2 MPa.

3.11.2 The castings of malleable cast iron shall be produced in accordance with international and national standards or works specifications. Castings of malleable cast iron produced in large quantities shall be manufactured at works recognized by the Register as specified in **1.1.4** and **1.3.1.4**.

3.11.3 Chemical composition and mechanical properties.

The chemical composition, mechanical properties and scope of testing of items made of malleable cast iron shall comply with the requirements of the documentation agreed with the Register.

3.11.4 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of **3.8.8.**

3.12 STEEL CASTINGS FOR PROPELLERS

3.12.1 General.

3.12.1.1 The requirements of this Chapter apply to steel castings for cast propellers, blades and bosses during their manufacture. If specified in the documentation agreed with the Register, these requirements may also be applied in the repair of propellers damaged in service.

The use of steel that is different in chemical composition, mechanical properties or heat treatment for propellers is permitted according to standards, specifications or other technical requirements recognized by the Register.

3.12.1.2 Propeller castings shall be manufactured by the works recognized by the Register in accordance with **1.1.4** and **1.3.1.4**. Specifications for material, the description of a technological process, repair and inspection shall be attached to a request for material.

3.12.1.3 Recognizing the works, tests are conducted in accordance with **1.3.5** on the basis of the survey and tests program approved by the Register. The tests shall confirm the compliance of castings material and their quality with these requirements.

3.12.1.4 A foundry shall have available a properly equipped laboratory manned with experienced qualified personnel. The laboratory shall have at its disposal everything necessary for the performance of non-destructive testing. However, if the laboratory is unable to conduct tests and inspection, the data on an independent laboratory shall be submitted to the Register. The laboratory shall be recognized by the competent national body and/or Register.

3.12.2 Chemical composition.

The chemical composition of the steel for propellers shall meet the requirements of Table 3.12.2.

The alloys in Table are subdivided into four main groups.

Table 3.12.2. **Chemical composition of steel for propeller castings** [1]

Steel grade and type	C, %, max	Mn, %, max	Cr, %	Mo, %, max	Ni, %
Martensitic (12Cr1Ni)	0,15	2,0	11,5–17,0	0,5	Max 2,0
Martensitic (13Cr4Ni)	0,06	2,0	11,5–17,0	1,0	3,5–5,0
Martensitic (16Cr5Ni)	0,06	2,0	15,0–17,5	1,5	3,5–6,0
Austenitic (19Cr11Ni)	0,12	1,6	16,0–21,0	4,0	8,0–13,0

[1] The minimum elements content not specified in Table shall meet the requirements of recognized national or international standards.

3.12.3 Mechanical properties and heat treatment.

3.12.3.1 The mechanical properties of steel during the testing of specimens prepared from samples cast-on to the hub or blade shall meet the requirements of Table 3.12.3.1.

3.12.3.2 The level of mechanical properties of the separately cast samples metal is subject to the approval by the Register.

3.12.3.3 Heat treatment.

Castings of martensitic class steel shall be subjected to austenization and tempering. Austenitic class steels shall be subjected to solution treatment.

Table 3.12.3.1. **Mechanical properties of steel castings for propellers**

Steel grade and type	Yield stress $R_{p0,2}$, MPa, max	Tensile strength R_m, MPa, max	Elongation, A_5, %, max	Reduction of area Z, %, max	Impact test[1] KV, min, J
Martensitic (12Cr1Ni)	440	590	15	30	20
Martensitic (13Cr4Ni)	550	750	15	35	30
Martensitic (16Cr5Ni)	540	760	15	35	30
Austenitic (19Cr5Ni)	180 ($R_{p1,0}$ = 205)	440	30	40	–

[1] The impact test is not required for ice class ships of **Ice1**, **Ice2** and **Ice3**; for all other ice class ships and for icebreakers, steel castings shall be impact-tested at -10°C.

3.12.4 Sampling.

3.12.4.1 Samples may be taken immediately from a casting or gated to it. Test specimens, where possible, are taken from the cast-on sample in the area within 0,5R to 0,6R (where R is a propeller radius).

The use of separately cast samples for machine specimens shall be specified in the approved documentation.

3.12.4.2 Separately cast samples shall be taken from the same ladle as the casting as the metal presented and heat treated in the same furnace charge. In the initial survey of a works in accordance with **3.12.1.2**, tests may be conducted in the metal of both separately cast and cast-on samples or taken directly from a casting body.

3.12.4.3 Samples shall not be taken from a casting prior to a final heat treatment. Samples are prepared in accordance with the standards recognized by the Register.

3.12.4.4 Thermal methods shall not be used for sampling.

3.12.5 Number of tests.

3.12.5.1 At least one tensile test specimen (refer to Table 2.2.2.3) and one set of impact test specimens (refer to **2.2.3**) shall be taken from each cast presented. In tensile tests, the tensile strength, proof stress, elongation and reduction in area are determined.

Test are conducted in compliance with the requirements of **2.2**.

3.12.5.2 Test specimens shall generally be cut out from cast-on samples. If castings are roughly of the same size, less than 1 m in diameter made from metal of one cast and heat treated in one furnace charge, one set of specimens for each 5 castings may be taken from separately cast samples of the relevant dimensions.

3.12.6 Severity zones (repair zones).

3.12.6.1 In order to define the criteria of assessment for propeller defects, the blade surface is divided into three zones designated *A*, *B* and *C* (refer to Figs. 4.2.6.2.1 and 4.2.6.3).

The definitions of repair zones are given in **4.2.6.2** i **4.2.6.3**.

3.12.6.2 The definition of a skew angle - refer to **4.2.6.1** (Note) and Fig. 4.2.6.1.

3.12.7 Inspection.

3.12.7.1 Propeller castings shall be visually tested at all the stages of their manufacture. The castings shall be subjected to a thorough 100 % visual testing in the finished condition (the inspection is conducted by the Register representative). A surface shall be free from the defects, which may result in propeller damages during operation.

The Register representative can demand the performance of investigation of questionable surface sections including metal etching, particularly prior to repair welding.

3.12.7.2 Dimensions, dimensional and geometrical tolerances shall meet the requirements of the drawings approved by the Register and of order documentation. The above documents and the results of measurements and inspection drawn up in the form of a report or statement are produced to the Register representative during tests. The responsibility for the performance of measurements with an appropriate accuracy for their compliance with the requirements of the drawing and/or order rests with a manufacturer. The Register representative has a right to demand checking measurements.

In accordance with the requirements of the Register-approved documentation, all propellers shall be subjected to static balancing. Dynamic balancing is required for propellers running with a rotational speed of over 500 rpm.

3.12.8 Non-destructive testing.

3.12.8.1 All the castings of propellers shall be subjected to non-destructive testing. A manufacturer shall have available an appropriate system to record all the non-destructive testing results for each casting.

The Register representative shall be familiarized with that system and the results of the testing carried out. The manufacturer duty shall confirm in the documentary form the true performance and the positive results of non-destructive testing methods.

3.12.8.2 Penetrant testing.

Penetrant testing shall be conducted in accordance with the standards or specification approved by the Register. The following definitions therewith are recommended to use.

Indication is the presence of detectable bleed-out of the penetrant from the material discontinuities appearing at least 10 minutes after the developer has been applied.

Linear indication is the indication, in which the length is at least three times the width (refer to Fig. 4.2.7.3.1(2).

Nonlinear indication is the indication of a circular or elliptical shape with a length less than three times the width (refer to Fig. 4.2.7.3.1(1).

Aligned indication is three or more indications in a line separated by 2 mm or less edge-toedge - (refer to Fig. 4.2.7.3.1(3).

Threshold sensitivity is the opening of a discontinuity like the isolated crack of a certain length detected with the given probability according to the given geometrical and optical parameters of an indication. The indication, any dimension of which is over 1,5 mm, may be considered as the isolated indication taken into account.

Reference area is an area of 100 cm^2, which may have square or rectangular shape with the major dimension not exceeding 250 mm. In evaluation of surface quality by penetrant testing, the entire controlled surface is conventionally divided in reference areas of 100 cm^2 each. Segmentation shall be the most unfavourable in relation to indications, i. e. the shape and dimensions of each reference area shall be chosen so that it covers the maximum number of defects without their distribution among adjacent reference areas.

The indications detected in any of such areas with respect to their shape, dimensions and number shall meet the requirements of Table 3.12.8.2.

Table 3.12.8.2. **Allowable number and size of indications depending on severity zone**

Severity zone	Total number of indications, max	Indication type	Number of indications of each type, max	Indication size, mm, max
A	7	non-linear	5	4
		linear	2	3
		aligned	2	3
B	14	non-linear	10	6
		linear	4	6
		aligned	4	6
C	20	non-linear	14	8
		linear	6	6
		aligned	6	6
Notes: 1. Singular non-linear indications less than 2 mm in zone A and less than 3 mm in other zones may be disregarded. 2. The total number of non-linear indications may be increased to the total allowable number of all type indications, represented by the absence of linear or aligned indications. The total number of non-linear indications may also be increased due to the partial lack of linear or aligned indications retaining the total allowable number of indications				

3.12.8.3 Radiographic and ultrasonic testing.

Where serious doubts exist that castings are not free from internal defects, further radiographic and/or ultrasonic testing shall be carried out upon request of the Register representative. The evaluation and acceptance criteria shall be agreed between the manufacturer, the customer and the Register according to the standards recognized by the Register.

3.12.9 Repair of defects.

3.12.9.1 Surface discontinuities, which impair propellers performance, shall be repaired by mechanical methods, e.g. by grinding, chipping and milling. The use of welding to repair defects is allowed only in justified cases to be agreed with the Register representative.

The repair of defects shall be carried out after producing the documentation with the full description of works to be conducted, to the Register representative.

The relevant repair zones, dimensions and location of defects, methods of their repair and inspection shall be specified.

After milling or chipping, grinding shall be applied for such defects, which shall not be welded. The grinding shall be carried out in such a manner that the contour of the ground depression is as smooth as possible to avoid stress concentration and/or minimize cavitation corrosion.

The metal for welding shall be properly selected and shall have the shape and dimensions needed for welding. The welding of areas less than 5 cm^2 shall be avoided.

3.12.9.2 Repair of defects in zone A.

In zone *A*, repair welding is not allowed. Grinding in zone *A* may be carried out to the extent, which maintains the blade thickness of the drawing approved by the Register.

The possible repair of defects by methods not specified here shall be approved as part of the submitted documentation.

3.12.9.3 Repair of defects in zone *B*.

The defects that are not deeper than dB = *t*/40 (*t* = minimum local thickness) or 2 mm (whichever is greater) may be removed by grinding.

defects, which are deeper than allowable for removal by grinding, may be repaired by welding.

3.12.9.4 Repair of defects in zone *C*.

In zone *C*, repair welds are generally permitted.

3.12.9.5 Repair welding. The welding procedure and welding consumables used for defects repair shall be recognized by the Register in accordance with the requirements of Part XIV "Welding".

Prior to the beginning of works on the repair of defects by welding, it shall be submitted the detailed specification of a welding procedure, which shall include data on the welding position, welding process parameters, welding consumables, preheating, follow-up heat treatment and inspection of welding operations conducted. Welding shall be conducted under controlled conditions, which prevent an adverse exposure to weather.

Defects shall be repaired by welders of a proper qualification, allowed by the Register to perform such works.

Slag, undercuts and other flaws shall be repaired prior to the following pass. Martensitic class steels after repair by welding are subject to annealing in a furnace.

The methods for the relief of local residual stresses with the minimum repair shall be agreed as part of the repair documentation.

Repaired surfaces after heat treatment shall be milled and ground. In all cases, the repair quality shall be checked by non-destructive testing methods.

A manufacturer shall maintain the system of defects recording, on which base the scope of a repair conducted, the type and schedules of heat treatment for any casting may be determined.

The entire information on the casting being subject to the Register survey is produced to the Register representative.

The approval of a welding procedure shall be based on the welding of samples as shown in Fig. 3.12.8.5.1, having the thickness of 30 mm or more. Following welding, the samples are subject to penetrant testing.

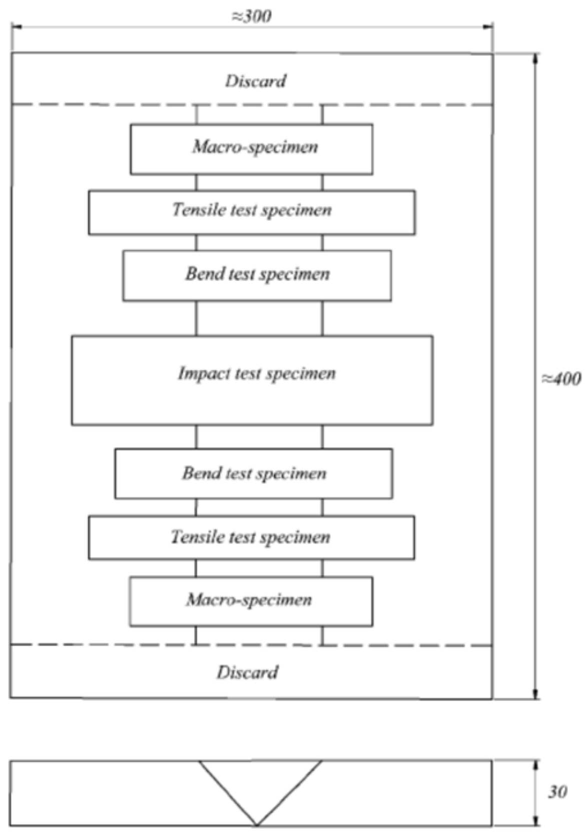


Fig. 3.12.8.5.1

The approval of a welding procedure is carried out in accordance with the requirements of Section **6**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships following the Registerapproved program, which shall include, as a minimum, the following tests.

Macro-examination of a fusion line and heat-affected zone.

Carried out on two macro-sections. Cracks, pores, slag inclusions and other weld flaws over 3 mm in size are not permitted.

Tensile testing for determination of weld metal properties.

Carried out on two transverse specimens, which thickness in equal to that of a sample, the width is 30 mm and the parallel test length is equal to the weld width plus 6 mm to each side (refer to **4.2.3.2.2**, Part XIV "Welding"). Mechanical properties shall meet those required for the base metal. The fracture area (weld metal, heat-affected zone or base metal) shall not beed in a test report.

Bend testing.

Carried out on two transverse specimens made in accordance with the requirements of 2.2.5.1. The test is conducted on a mandrel four thickness in diameter excepting austenitic steels, for which the mandrel diameter shall be equal to three thicknesses. After the tests, the specimen surface shall be free from tension fractures and cracks of more than 2 mm long.

Impact testing.

The tests are not generally required excepting the cases when a base metal was subjected to these tests. Where necessary, impact tests are conducted on specimens made in accordance with 2.2.3 and Fig. 2.2.3.1-2.

The tests shall be conducted on one batch of specimens notched in the weld centre and on another one notched in the fusion line. The temperature and results of the tests shall meet those required for the base metal.

Hardness testing according to Vickers (HV5).

Carried out on macro-sections. Three measurements each are, as a minimum, made on the weld metal, heat-affected zone, at both sides of a weld and in the base metal. The measurements are noted in a test report.

3.12.10 Identification and marking.

3.12.10.1 Identification.

A monitoring system enabling to check the castings manufacture at any stage since metal making shall be used at the works manufacturing propellers.

The confirmation of the availability of such system at the manufacturer's shall be submitted to the Register representative on his demand.

3.12.10.2 Marking.

A casting shall be properly marked prior to its presentation in the finished condition to the Register representative. In addition to specified in 1.4, the marking shall include the following data:

casting number and other designations allowing tracing all the stages of manufacture;

number of the Register Certificate;

skew angle (for high-skew propellers);

ice class symbol, where applicable;

date of casting acceptance.

The Register stamp is put following the final survey and the acceptance of a casting by the Register representative.

3.12.10.3 Manufacturer's Certificate. The Manufacturer's Certificate for a casting shall be submitted to the Register representative simultaneously with the presentation of the casting in the finished condition or in good time. The Certificate shall be verified by the quality service of a works and witnessed by the person authorized for this by the works.

The Certificate shall contain the following data:

manufacturer's name and order number;

shipbuilding project number, if known;

description of the casting with drawing number;

propeller diameter, number of blades, pitch and directions of turning;

final weight;

grade and type of alloy, number of a cast and chemical composition;

identification number;

heat treatment schedule;

results of mechanical tests;

result of non-destructive testing (satisfactory or unsatisfactory), if applied.

3.12.10.4 The Register Certificate.

Each casting or the batch of small castings shall be accompanied with the Register Certificate.

In addition to the special number, the requisites of the Register representation or location, the place and date of issue, the Register Certificate is, as a minimum, to contain the following data:

manufacturer's name and order number;

shipbuilding project number, if known;

number of the certificate of quality of the casting manufacturer;

final weight;

identification number and casting number; drawing number.

The Manufacturer's Certificate be the mandatory appendix to the Register Certificate. Test protocols witnessed by the Register representative may also be part of the appendix to the Register Certificate on the purchaser's demand.

3.13 HIGH STRENGTH STEEL FOR WELDED STRUCTURES

3.13.1 General.

The present requirements apply to hot-rolled, fine-grain, weldable plates and wide flats of high strength steel subject to the survey by the Register during manufacture and intended for use in sea-going ships and and in MODU/FOP.

Proceeding from the minimum yield stress guaranteed the steel is subdivided into eight strength levels: 420, 460, 500, 550, 620, 690, 890 and 960 MPa. For each yield strength level grades A, D, E and F are specified, based on the impact test temperature, except for yield strength level of 890 and 960 MPa for which grade F is not applicable.

The requirements for the hot-rolled products with thickness of 15 mm or less designed for operation at design temperatures below -30°C, are specified in **3.5.2.6**. High strength steel is manufactured at works recognized according to **1.3.1.4**.

The attention of the consumers shall be drawn to the fact that when fatigue loading is present, the effective fatigue strength of a welded joint of high strength steel may not be greater than that of a welded joint in normal strength steels.

Before subjecting steels produced by thermomechanical rolling to further heating for forming or stress relieving, or using high heat-input welding, special consideration shall be given to the possibility of a consequent reduction in mechanical properties.

3.13.2 Steel making process.

Vacuum degassing shall be used for any of the following:

all steels with enhanced through-thickness properties;

all steels of grades 690, 890 and 960.

The steel shall be fully killed, fine grain treated and shall have fine grain structure. The fine grain practice is to be as detailed in the approved manufacturing specification.

A fine grain structure has an equivalent index ≥6 determined by micrographic examination in accordance with ДСТУ ISO 643 or alternative national or international test method agreed with the Register.

The steels shall contain nitrogen binding elements as detailed in the manufacturing specification. Also refer to Table 3.13.3.1.

3.13.3 Chemical composition.

3.13.3.1 The chemical composition of steel shall be determined by the manufacturer from each cast or ladle in an adequately equipped laboratory.

The chemical composition of steel shall be in accordance with the specification approved by the Register and the limiting values given in Table 3.13.3.1.

Table 3.13.3.1 **Chemical composition of high strength steel**

Delivery condition[1]	N/NR		TM		QT	
Steel grade	A420 D420 A460 D460	E420 E460	A420 D420 A460 D460 A500 D500 A550	E420 F420 E460 F460 E500 F500 E550	A420 D420 A460 D460 A500 D500 A550	E420 F420 E460 F460 E500 F500 E550

			D550 A620 D620 A690 D690 A890	F550 E620 F620 E690 F690 D890 E890	D550 A620 D620 A690 D690 A890 A960	F550 E620 F620 E690 F690 D890 E890 D960 E960
Chemical Composition, %[2]						
C_{max}	0,20	0,18	0,16	0,14	0,18	
Mn	1,0 – 1,7				1,70	
Si_{max}	0,60				0,80	
P_{max}[3]	0,030	0,025	0,025	0,020	0,025	0,020
S_{max}[3]	0,025	0,020	0,025	0,010	0,015	0,010
Al_{total} **min**[4]	0,02				0,18	
Nb_{max}[5]	0,05				0,06	
V_{max}[5]	0,20		0,12		0,12	
Ti_{max}[5]	0,05				0,05	
Ni_{max}[6]	0,80		2,00		2,00	
Cu_{max}	0,55				0,50	
Cr_{max}[5]	0,30		0,50		1,50	
Mo_{max}[5]	0,10		0,50		0,70	
N_{max}	0,025				0,015	
Oxygen ppm_{max}[7]	--		--	50	--	30

Notes :[1] Refer to **3.13.4** for definition of delivery conditions.

[2] The chemical composition is to be determined by ladle analysis and shall meet the Register approved manufacturing specification at the time of approval.

[3] For sections the P and S content can be 0.005% higher than the value specified in the table.

[4] The total aluminium to nitrogen ratio shall be a minimum of 2:1 in case no other nitrogen binding elements are used.

[5] Total Nb+V+Ti < 0.26% and Mo+Cr < 0.65% not applicable for QT steels.

[6] Higher Ni content may be approved at the discretion of the Register.

[7] The requirement on maximum Oxygen content is only applicable to D890, E890, D960 i E960.

3.13.3.2 The content of elements used for alloying, nitrogen binding, and fine grain treatment, and as well as the residual elements shall be detailed in the manufacturing specification. For example, when boron is intentionally added for enhancement of hardenability of the steels, the maximum boron content shall not be higher than 0,005%.

3.13.3.3 The carbon equivalent value shall be calculated from the ladle analysis. Maximum values are specified in Table 3.13.3.3.

Table 3.13.3.3 **Maximum C_{eq}, CET and P_{cm} values for high strength steel**

Steel grade and delivery condition	Carbon Equivalent (%)							
	C_{eq}						**CET**	P_{cm}
	Plates			Section	Bars	Tubulars	all	all
	t≤50 мм	50<t≤100 мм	100<t≤250 мм	t≤50 мм	t≤250 або d≤250 мм	t≤65 мм		
420N/NR 420TM 420QT	0,46 0,43 0,45	0,48 0,45 0,47	0,52 0,47 0,49	0,47 0,44 --	0,53 -- --	0,47 -- 0,46	-- -- --	-- -- --
460N/NR 460TM	0,50 0,45	0,52 0,47	0,54 0,48	0,51 0,46	0,55 --	0,51 --	0,25 0,30	-- 0,23

460QT	0,47	0,48	0,50	--	--	0,48	0,32	0,24
500TM 500QT	0,46 0,48	0,48 0,50	0,50 0,54	-- --	-- --	-- 0,50	0,32 0,34	0,24 0,25
550TM 550QT	0,48 0,56	0,50 0,60	0,54 0,64	-- --	-- --	- 0,56	0,34 0,36	0,25 0,28
620TM 620QT	0,50 0,56	0,52 0,60	-- 0,64	-- --	-- --	-- 0,58	0,34 0,38	0,26 0,30
690TM 90QT	0,56 0,64	-- 0,66	-- 0,70	-- --	-- --	-- 0,68	0,36 0,40	0,30 0,33
890TM 890QT	0,60 0,68	-- 0,75	-- --	-- --	-- --	-- --	0,38 0,40	0,28 --
960QT	0,75	--	--	--	--	--	0,40	--

Calculation formulas are given below:

for all steel grades the following formula may be used:

$C_{eq}= C + M_n/6 + (C_r+M_o+V)/5 + (N_i+C_u)/15$ (%) (3.13.3.3-1)

for steel grades H460 and higher, CET may be used instead of C_{eq} at the discretion of the manufacturer, and shall be calculated according to the following formula:

$CET = C+ (M_n+ M_o)10 + (C_r+C_u)20 + N_i/40$ (3.13.3.3-2)

Note: The CET is included in the standard EN 1011-2:2001 used as one of the parameters for preheating temperature determination, which is necessary to avoid cold cracking;

for TM and QT steels with carbon content not more than 0,12 %, the cold cracking susceptibility P_{cm} shall be be calculated using the following formula:

$P_{cm}= C + S_i/30 + M_n/20 + C_u/20 + N_i/60 + C_r/20 + M_o/15 + V/10 + 5B$ (%) (3.13.3.3-3)

3.13.4 Condition of supply.

Steel shall be delivered in accordance with the processes approved by the Register. These processes include:

Normalized (N)/Normalized rolled (NR);

Thermo-mechanical controlled rolled (TM)/with Accelerated cooling (TM+AcC)/with direct quenching followed by tempering (TM+DQ);

Quenched and Tempered condition (QT).

The definition of these delivery conditions are specified in **3.2.1.4**

Direct quenching after hot-rolling followed by tempering is considered equivalent to conventional quenching and tempering.

3.13.5 Rolling reduction ratio.

The rolling reduction ratio shall be not less than 3:1 unless otherwise agreed at the time of approval.

3.13.6 Thickness limits for approval

3.13.6.1 The maximum thickness of slab, billet or bloom from the continuous casting process shall be at the manufacturer's discretion.

3.13.6.2 Maximum thickness of plates, sections, bars and tubulars, over which a specific delivery condition is applicable, are shown in Table 3.13.6.2**.**

Table 3.13.6.2 **Maximum thickness limits**

Delivery condition	**Maximum thickness (mm)**			
	Plates	Sections	Bars	Tubulars
N	250 [1]	50	250	65
NR	150	[2]		
TM	150	50	--	--
QT	150 [1]	50	--	50

Notea:

[1] Manufacturing process of N steels with thickness larger than 250 mm and QT steels with thickness larger than 150 mm shall be approved by the Register.

[2] The maximum thickness limits of sections, bars and tubulars produced by NR process route and shall be specified in the technical documentation approved by the Register.

3.13.7 Mechanical properties.

For the purpose of tensile and impact testing, the mechanical properties of steel shall be in accordance with Tables 3.13.7-1 and 3.13.7-2. Where rolled products of other shapes (sections, construction pipes, etc.) are tested, the elongation required for longitudinal specimens shall exceed that stated in Tables 3.13.7-1 and

3.13.7-2 by 2 %.

Table 3.13.7-1 **Mechanical properties for extra high strength steel**

Mechanical properties / Steel grade & delivery condition		Yield strength R_{eH}[1] **min (MPa)** Nominal thickness (мм)[2]			Tensile strength **R_m (MPa)** Nominal thickness (мм)[2]		Minimum percentage elongation after fracture (%) **$L_o=5,65\sqrt{S_o}$**[3]		Impact energy, average **min, (J)**		
		3<t≤ 50	**50<t≤ 100**	**100<t ≤ 250**	**3<t≤ 100**	**100<t≤ 250**	**T**	**L**[4]	Test temp (°C)	**T**	**L**
1		**2**	**3**	**4**	**5**	**6**	**7**	**8**	9	**10**	**11**
420N/NR 420TM 420QT	A D E F	420	390	365	520-680	470-650	19	21	0 -20 -40 -60	28	42
460N/NR 460TM 460QT	A D E F	460	430	390	540-720	500-710	17	19	0 -20 -40 -60	31	46
500TM 500QT	A D E F	500	480	440	590-770	540-720	17	19	0 -20 -40 -60	33	50
550TM 550QT	A D E F	550	530	490	640-820	590-770	16	18	0 -20 -40 -60	37	55
620TM 620QT	A D E F	620	580	560	700-890	650-830	15	17	0 -20 -40 -60	41	62
690TM 690QT	A D E F	690	650	630	770-940	710-900	14	16	0 -20 -40 -60	46	69
890TM 890QT	A D E	890	830	--	940-1100	--	11	13	0 -20 -40	46	69
960TM	A D E	960	--	--	980-1150	--	10	12	0 -20 -40	46	69

Notes: **1** For tensile test either the upper yield stress (*R_{eH}*) or where *R_{eH}* cannot be determined, the 0,2 % proof stress (*$R_{p0.2}$*) is to be determined and the material is considered to comply with the requirement if either value meets or exceeds the specified minimum value of yield strength.

2 For plates and sections for applications, such as racks in offshore platforms etc., where the design requires that tensile properties are maintained through the thickness, a decrease in the minimum specified tensile properties is not permitted with an increase in the thickness.

3 For full thickness flat test specimens with a width of 25 mm and a gauge length of 200 mm the elongation shall comply with the minimum values shown in Table **3.13.7-2**.

4 In the case that the tensile specimen's longitudinal axis is parallel to the final rolling direction, the test result shall comply with the requirement of elongation for longitudinal (L) direction

Table 3.13.7-2 **Elongation minimum values for flat tensile specimens** [1]

Strength level, MPa	Thickness (mm)						
	≤10	**>10≤15**	**>15≤20**	**>20≤25**	**>25≤40**	**>40≤50**	**>50≤70**
420	11	13	14	15	16	17	18
460	11	12	13	14	15	16	17
500	10	11	12	13	14	15	16
550	10	11	12	13	14	15	16
620	9	11	12	12	13	14	15
690	9[2]	10[2]	11[2]	11	12	13	14

Notes: [1] The tabulated elongation minimum values are the requirements for testing specimen in transverse direction. RU890 and RU960 specimens and specimens which are not included in this table shall be proportional specimens with a gauge length of $L_o = 5.65\sqrt{S_o}$.
[2] For 690 plates with thickness ≤20 mm, round specimen in accordance with 2.1 may be used instead of the flat tensile specimen. The minimum elongation for testing specimen in transverse direction is 14 %

3.13.8 Sampling and testing.

Test specimens and test procedures for mechanical properties are in accordance with **2.2** and **3.1**.

3.13.8.1 Tensile test.

Test specimens shall be cut with their longitudinal axes transverse to the final direction of rolling, except in the case of sections, bars, tubulars and rolled flats with a finished width of 600 mm or less, where the direction of the tensile specimens shall be agreed with the Register. As a rule, full thickness flat tensile specimens shall be prepared in such a manner as to maintain the rolling scale at least at one side.

Alternatively, if the machined round test specimens are used, they shall be located at a position lying at a distance of (t/4) from the surface or as near as possible to this position.

Where test results are unsatisfactory, retesting shall be conducted in compliance with the requirements of **1.3.4**.**2**.

3.13.8.2 Impact test.

3.13.8.2.1 Unless otherwise agreed with the Register, the impact testing of steel plates and wide flats of more than 600 mm in width shall be effected on specimens prepared in accordance with 2.2.3.1-2, the longitudinal axes of which are perpendicular to the direction of rolling (transverse specimens). Where rolled products of another cross-sectional shape are concerned, the impact testing shall be effected on longitudinal specimens.

3.13.8.2.2 Sub-surface test specimens will be taken in such a way that one side is not further away than 2 mm from a rolled surface, however, for material with a thickness in excess of 50 mm, impact tests shall be taken at the quarter thickness (t/4) and mid-thickness (t/2) location.

3.13.8.2.3 Impact test for a nominal thickness less than 6 mm are normally not required.

3.13.9 Scope of testing.

Each plate (rolled length) shall undergo tensile and impact testing after heat treatment.

For rolled products quenched and tempered in continuous furnaces, the scope of testing, including the number of specimens and the direction of their cutting out, is determined on the basis of the specification approved by the Register.

Out of each test sample, at least one tensile specimen and three impact test specimens shall be prepared. If required by the Register, tensile testing shall be made on specimens with their longitudinal axes perpendicular to the plate surface and the reduction in cross-sectional area shall be determined.

3.13.10 Inspection.

Rolled products shall comply with all the requirements of **3.2.7** taking the provisions below into consideration.

When surface defects are eliminated by grinding, the thickness of the rolled products at the ground spot shall not exceed permitted tolerances.

When required by the Rules, the rolled products shall undergo the ultrasonic testing in conformity with standards recognized by the Register.

3.13.11 Marking and documentation. Identification, marking and issued documentation shall comply with the requirements of **3.2.9.**

3.14 Z-STEEL

3.14.1 General.

The present requirements apply to steel of normal, higher (refer to **3.2** and 3.5), high strength (refer to 3.13) having thickness equal to or more than 15 mm. Application of the requirements set forth is possible also for rolled steel with thickness less than 15 mm.

Z-steel is recommended for use for welded structures taking up considerable stresses perpendicular to rolled surface. The present requirements define two levels of Z-properties for steel. Two relevant notations: Z25 and Z35 are introduced.

Rolled products shall be manufactured by works recognized by the Register (refer to **1.3.1.4**). The manufacturer shall prove that the manufacturing process provides guaranteed plastic properties in the through rolling thickness direction.

At appropriate guarantees of the manufacturer a supply of steel with determination of the reduction in area Z_z of the rolled products with a thickness specified in the documentation agreed with the Register is permitted.

Provision is made for calcium treatment, vacuum degassing, argon stirring, sulphur segregation control, etc.

3.14.2 Chemical composition.

3.14.2.1 Z-steel shall be fully killed and fine grain treated.

The contents of elements shall comply with the national or international standards recognized by the Register.

The content of sulphur (ladle analysis) in Z-steel shall not exceed 0,008 %.

3.14.3 Mechanical properties.

The mechanical properties of the steel, unless otherwise specified, shall meet the requirements of **3.2**, **3.5** and **3.13**.

For the appropriate level of Z-properties, the average value of the reduction in area Zz obtained upon tension of three specimens, the longitudinal centreline of which is perpendicular to rolled surface, shall comply with Table 3.14.3-1. Table 3.14.3-1 gives for each level of Z-properties the value of the reduction in area to which the area is allowed to reduce on one of the specimens.

The need for retest on additional set of three specimens cut out from the same rolled product (refer to **2.2.2.5**) and acceptance of test results including also retest results as satisfactory is shown in Table 3.14.3-2.

Table 3.14.3-1

Level of Z-properties	Z25, %	Z35, %
Minimum average value of the reduction in area	25	35
Minimum allowable value of the reduction in area on one specimen	15	25

The Table 3.14.3-2 gives boundary cases taken into account by the Rules:

case of satisfactory tests on three specimens;

three cases where retest is permitted;

case of retest of six specimens (three completed plus three additional).

The retest results are considered to be satisfactory and the rolled product/batch is accepted for supply, provided:

the average value of the reduction in area Z_z, obtained as a result of testing six specimens exceeds the required minimum average value (refer to Table 3.14.3-2), the results less than the mentioned required value have been obtained on not more than two specimens out of six;

Table 3.14.3-2

Tests			Retest
Minimum required value of the reduction in area	Acceptable result	Unacceptable result where retest is required	Acceptable result
	O—┬—O Δ	O—┬—O O O │ Δ │	OOOO Δ
Minimum allowable value of the reduction in area on one specimen	│ O	Δ │ Δ O O—┴—O O—┴—O	O—┴—O
O — individual result; Δ — average result.			

Where the retest results are unsatisfactory the rolled product/batch submitted shall be rejected. Additional tests (on the same conditions) are permitted for each rolled product (other than that already tested) out of the batch rejected.

3.14.4 Sampling and scope of testing.

The scope of testing depends on the type of rolled product and content of sulphur (ladle analysis). The scope of testing shall be determined in accordance with Table 3.14.4.

Samples shall be taken from one end of the semi-finished product submitted for tests, as indicated in **2.2.2.5**.

3.14.5 Inspection.

Besides fulfilment of the requirements of **3.2.7**, all the rolled products shall be subject to ultrasonic testing at the final stage of manufacture. The ultrasonic testing shall be carried out in compliance with the requirements of ДСТУ EN 10160 or the relevant standard EN, (level S2/E1), ASTM A578 (level C at a frequency of 4 MHz) or with the Register-approved national standards.

3.14.6 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of **3.2.8**. Besides, to the steel designation mentioned Z25 or Z35 shall be added, respectively, (e.g., DH36225).

Table 3.14.4

Type of rolled product	Content of sulphur, %	
	S > 0,005	S ≤ 0,005
Plate	Each plate	One plate out of maximum 50 t of products of the same cast, thickness and heat treatment
Wide flats of thickness t≤ 25 mm	Maximum 10 t of products of the same cast, thickness and heat treatment	Maximum 50 t of products of the same cast, thickness and heat treatment
Wide flats of thickness t > 25 mm	Maximum 20 t of products of the same cast, thickness and heat treatment	Maximum 50 t of products of the same cast, thickness and heat treatment

3.15 WIRE ROPES

3.15.1 General.

3.15.1.1 The present requirements apply to ropes, subject to the Register survey, which are intended for cargo-handling gear, life-saving appliances and other ship appliances.

3.15.1.2 The ropes shall be manufactured and tested in conformity with standards approved by the Register and by works recognized by that body according to **1.3.1.4**.

3.15.2 Manufacture.

3.15.2.1 For the manufacture of ropes wire with a coating to protect it from corrosion and a tensile strength not less than 1180 MPa shall be used.

3.15.2.2 The organic fibre core of ropes shall be manila, sizal, hemp or synthetic fibre. Ropes with the diameter more than 12 mm shall have a core of three strands.

3.15.2.3 Cores of organic fibre shall be impregnated or lubricated with corrosion preventive or anti-rot substances not solvable in sea water and containing no acids or alkalis. The lubricant for the ropes and the impregnant for the organic-fibre cores shall be compatible by their physical and chemical properties.

3.15.3 Sampling.

For testing purposes, from each rope 2000 m or less long a sample length shall be taken, and from ropes longer than 2000 m a sample length shall be taken from both ends. The sample lengths shall be long enough to make all the required testing possible.

3.15.4 Scope of testing.

3.15.4.1 After manufacture, each rope shall undergo the following tests:

breaking test of rope as a whole;

tensile test (ultimate strength being determined), bend test, twisting test and testing of the bond between the coating and steel core on wires from the rope.

The number of wires to be tested may be determined on the basis of standards, but not less than 10 % of the total number of wires in a group of wires of a particular diameter shall be tested.

3.15.4.2 Testing shall be conducted in accordance with approved standards. The breaking test of the rope as a whole shall be effected by means of a breaking machine having the distance between the clamps not less than 50 rope diameters. If during testing the rope breaks less than 50 mm away from the grip the test shall be repeated.

3.15.4.3 The test results shall be in accordance with standards.

3.15.4.4 Under conditions of an established manufacturing process and in the event of testing equipment of the required capacity being not available to enable the breaking test of a rope as a whole the breaking load may be determined proceeding from the results of the tensile test, F, in kN, of all the wires making up the rope on the basis of the formula

$$F = c\sum_{1}^{i}\left(\left(\sum_{1}^{m} F_m\right) n/z\right),$$

where c – wire efficiency factor for the rope, which shall be adopted on the basis of standards or calculated as the ratio of the breaking load of the rope as a whole to the total breaking load of all the wires making up the rope, both the values being stipulated by the standards;

i – number of groups of wires of the same diameter;

m – number of wires from each group of a particular diameter, subjected to tensile testing, which conform to Register approved standards;

F_m – the greatest load, during the tensile test of a wire, kN, after which the specimen breaks;

n – number of wires in each group of a particular diameter;

z – number of wires from each group of a particular diameter subjected to tensile testing.

Proceeding from the intended application of the rope, the number of wires to be tensile tested may be reduced, but in no case to less than 25 % of the total number of wires in the rope.

3.15.5 Inspection.

3.15.5.1 The compliance of the structure, diameter and other parameters of the rope to standards shall be confirmed by visual testing.

3.15.5.2 When bends or burn-off spots are removed from the ends of unstrandable ropes the strands and wires in the strands shall not uncoil or may uncoil in such a way that they can be easily returned to their initial position.

3.15.5.3 The rope diameter shall be determined on a slack rope at right angles to the axis between two opposite strands in two positions.

The rope diameter shall not exceed the design value by more than 6 %.

3.15.5.4 On the rope surface, twisting and bending of strands, sinking, crossing, corrosion and breaking of wires in strands that prevent using the rope in accordance with the purpose are not permitted.

3.15.6 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of **1.4**.

3.16 STAINLESS STEEL

3.16.1 General.

3.16.1.1 These requirements apply to stainless steel subject to the Register survey as required in other Parts of the Rules. The Chapter includes the requirements for stainless steel rolled plates and bars, forgings and pipes of martensitic (M), martensitic + ferritic (MF), ferritic (F), austenitic + martensitic (AM), austenitic (A) and austenitic + ferritic (AF) classes. The assumed classification of stainless steel depending on its chemical composition and structure is given in Table **3.16.1.1.**

Steel designations are based on the designations used in international standards.

Designations of national steel marks are given in accordance with the State standard.

Corrosion resistant steel used as an alternative means of providing corrosion protection (protective coatings) of cargo tanks of oil tankers specified in **1.2.5.3**, Part II "Hull" shall meet the requirements of IMO resolution MSC.289(87) with MSC.1/Circ.1478.

3.16.1.2 Corrosion-resistant steel shall be manufactured under the supervision of the Register by enterprises recognized in accordance with **1.3.1.2**.

Materials meeting the Register requirements shall be supplied with the Register Certificates.

Manufacturers' Certificates for ingots and blanks with indication of the manufacturer, steel mark, heat No., chemical composition and documentation, in compliance with which ingots/blanks were manufactured, shall be submitted to the surveyor to the Register who carries out the survey at the manufacturer's where there are no melting processes.

The enterprise that manufactures ingots/blanks shall be recognized by the Register.

3.16.1.3 Застосування нержавіючої сталі, яка не відповідає цим вимогам за хімічним складом, механічними властивостями і/або станом постачання, може бути допущено після детального вивчення властивостей сталі в умовах, для роботи в яких сталь призначається.

3.16.1.4 The use of stainless steel not meeting the requirements for chemical composition, mechanical properties and/or condition of supply may be permitted after detailed study of steel properties under the conditions, for which the steel is intended.

Table 3.16.1.1. **Assumed classification of stainless steel depending on chemical composition and structure**

Steel class	**Steel designation**	**Steel mark**		**Temperature range for application, ºC**
		AISI/UNS	National	
M-1	X20Cr13	410	20X13	–20 ... +450
		420	30X13	
	X7CrNiNb16 4	–	07X16H4Б	–60 ... +350
MF-2	X15CrNi17	431	14X17H2	–20 ... +350
F-3	X8CrTi17	430Ti	08X17T	0 ... +600
AM-4	X8CrNiTi17 6	–	08X17H6T	–60 ... +250
A-5	X10CrNiTi18 10	321, 347	08X18H10T	–165 ... +600
			12X18H10T	
	X2CrNi19 11	304L, 304LN	–	–165 ...+600
A-6	X10CrNiMo17 13 2	316L, 316LN	03X17H14M3	–165 ...+600
	X2CrNiMo18 13 3	317L, 317LN	–	–165 ... +600
	X10CrNiMoTi17 13 3	–	10X17H13M3T	–165 ... +600
A-7	X2CrNiMoCu20 18 6	S31254	–	–165 ... +600
	X2CrNiMoCu21 23 4 2	N08904	–	–165 ... +600
AF-8	X2CrNiMo22 5 3	S31803	03X22H6M2	–40 ... +250
	X3CrNiMo25 6 3	S31260	–	–40 ... +250
	X4CrNiVo25 5 3	S32550	–	–40 ... +250
	X2CrNiMo25 7 4	S32750	–	–40 ... +250
	X3CrNiMo25 7 3	S32760		–40 ... +250
	X10CrNiTi22 6	–	08X22H6T	–40 ... +250
	X10CrNiMo21 6 2	–	08X21H6M2T	–40 ... +250

3.16.1.5 Chemical composition and mechanical properties.

Chemical composition and mechanical properties. Chemical composition and mechanical properties of semi-finished products of stainless steel, as well as steel resistance to environmental effects shall meet the requirements of this Part of the Rules and also the requirements of national and international standards or other special documents recognized by the Register.

The chemical composition of stainless steel to be determined for each heat shall meet the requirements of Tables 3.16.1.5- 1 and 3.16.1.5-2. Where necessary, samples may be taken, on the Register request, directly from a semi-finished product (plate, forging, etc.).

The requirements for mechanical properties of semi-finished products depending on their type are given in Tables 3.16.2.2-1, 3.16.3.2-1, 3.16.3.2-2 and 3.16.4.2.

3.16.1.6 Condition of supply.

All semi-finished products shall be supplied in heat-treated condition. Heat treatment conditions are specified in accordance with standards recognized by the Register or other normative documents.

Where heat treatment conditions are not indicated in the standards, such conditions shall be specified in accordance with the standards and other normative technical documentation approved by the Register.

Steel plates and flats of 4 mm in thickness and less may be supplied in semi-cold-worked or coldworked condition.

Type or conditions of heat treatment shall be indicated in the Manufacturer's Certificate for the SemiFinished Product.

3.16.1.7 Sampling.

Samples are taken from a semi-finished product. For forgings separately forged samples prepared from the metal of the same heat and with the same degree of deformation as the semi-finished product submitted for the tests may be used.

In such case, dimensions of the sample in terms of their thickness and diameter may vary from the maximum dimensions of the forging itself by not more than 25 %.

Samples for preparation of specimens shall be cut out upon completion of all types of heat treatment. Separately forged samples shall be subjected to all types of process heating and heat treatment in one charge with the forging submitted for the tests.

The dimensions of samples shall provide performance of the required and possible retests.

Unless expressly provided otherwise, samples shall be taken as follows: rolled stock - in compliance with **3.2.5**.

Samples for impact tests shall be cut in such a manner that the longitudinal axis of specimens is transverse to the last direction of rolling.

For steel sections and bars longitudinal specimens may be used. For a semi-finished product having a size (diameter, square side, diameter of inscribed circle) under 40 mm the specimen axis shall coincide with the axis of the semifinished product;

Table 3.16.1.5-1. **Chemical composition of stainless steel**

Steel class and mark	Content of elements, %									
	C, не більше	Si	Mn	P	S	Cr	Ni	Mo	N	Other
Martensitic										
410	0,12	1,0	1,0	0,045	0,03	12,0–14,0	–	–	–	–
420	0,17	1,0	1,0	0,045	0,03	12,0–14,0	–	–	–	–
Martensite - ferritic										
431	0,23	1,0	1,0	0,045	0,03	16,0–18,0	1,5–2,5	–	–	–
Ferritic										
431Ti	0,1	1,0	1,0	0,045	0,03	16,0–18,0	–	–	–	TixC
Austenitic										
304L	0,03	1,0	2,0	0,045	0,03	17,0–20,0	8,0–13,0	–	0,10	–
304LN	0,03	1,0	2,0	0,045	0,03	17,0–20,0	8,0–12,0	–	0,10–0,22	–
316L	0.03	1,0	2,0	0,045	0,03	16,0–18,5	10,0–15,0	2,0–3,0	0,10	–
316LN	0,03	1,0	2,0	0,045	0,03	16,0–18,5	10,0–14,5	2,0–3,0	0,10–0,22	–
317L	0,03	1,0	2,0	0,045	0,03	18,0–20,0	11,0–15,0	3,0–4,0	0,10	–

317LN	0,03	1,0	2,0	0,045	0,03	18,0–20,0	12,5–15,0	3,0–4,0	0,10–0,22	–
321	0,08	1,0	2,0	0,045	0,03	17,0–19,0	9,0–12,0	–	0,10	Ti≥5xC≤0,70
347	0,08	1,0	2,0	0,045	0,03	17,0–19,0	9,0–13,0	–	0,10	Nb≥10xC≤1,0
UNS S31254	0,02	0,8	1,0	0,03	0,01	19,5–20,5	17,5–18,5	6,0–6,5	0,18–0,22	Cu 0,50–1,0
UNS N08904	0,02	1,0	2,0	0,04	0,025	19,0–23,0	23,0–28,0	4,0–5,0	0,15	Cu 1,00–2,0
Austenite - ferritic (duplex)										
UNS S31260	0,03	0,75	1,0	0,03	0,03	24,0–26,0	5,5–7,5	2,5–3,5	0,10–0,30	Cu 0,2–0,8 W 0,1–0,5
UNS S31803	0,03	1,0	2,0	0,03	0,02	21,0–23,0	4,5–6,5	2,5–3,5	0,08–0,20	–
UNS S32550	0,04	1,0	1,5	0,04	0,03	24,0–27,0	4,5–6,5	2,0–4,0[1]	0,10–0,25	Cu 1,5–2,5
UNS S32750	0,03	0,8	1,2	0,035	0,02	24,0–26,0	6,0–8,0	3,0–5,0	0,24–0,32	Cu 0,50, не більше
UNS S32760	0,03[2]	1,0	1,0	0,03	0,01	24,0–26.0	6,0–8,0	3,0–4,0	0,20–0,30	Cu 0,50–1,0 W 0,50–1,0
[1] For pipes content of Mo is taken equal to 2,90–3,90. [2] For pipes content of C ≤ 0,05.										

forgings - in compliance with **3.7.5.1**, sample being taken from the feed head of the ingot.

Samples may be taken at a distance of 1/3 of the radius or 1/6 of the diagonal from the outer surface of the forging or from the centre of the forging; pipes - in compliance with **3.4.5** and **3.4.6**.

Samples for intergranular corrosion tests shall be taken similarly to those for tensile tests. In any case, schemes of taking samples and cutting out specimens shall be indicated on the sketch.

3.16.1.8 Scope of tests.

3.16.1.8.1 Types of tests, to which stainless steel can be subjected during manufacture, are given in Table 3.16.1.8.1. Tests, to which stainless steel supplied under the Register technical supervision shall be subjected, are marked with «+».

As a rule semi-finished products of stainless steel are submitted for tests in batches or individually. A batch shall consist of semi-finished products of the same steel mark, the same heat, the same condition of supply, one shape (type) and size and made using the same production process.

Forgings of one batch shall be made according to the sketch and heat-treated in one charge.

Pipes included in the batch shall have the same wall thickness.

Steel plates and forgings intended for use at temperatures below zero shall be submitted for tests individually.

Sizes of batches, number and procedure of taking samples for steel plates, sheet steel and bars are given in **3.16.2.3**, for forgings – in **3.16.3.3**, for pipes – in **3.16.4.3**.

3.16.1.8.2 Tests for the recognizing an enterprise as a manufacturer of stainless steel in accordance with **3.16.1.2** shall be carried out under a program approved by the Register and generally shall include:

chemical analysis;

determination of mechanical properties (R_m, $R_{p0,2}$, A_5, Z) at 20 °C and a design temperature;

determination or confirmation of the critical brittleness temperature (except for austenitic type steels);

metallographic examination and macrostructure examination to detect shrinkage cavities, bubbles, non-metallic inclusions, grain size;

tests for susceptibility to intergranular, through, crevice, pitting corrosion;

determination of α- phase amount (for austenitic type steels);

process tests (ring expanding, flattening, bending, etc) and plasticity assessment in case of cold stamping.

3.16.1.8.3 3 Testing procedures, types and dimensions of specimens shall comply with the requirements of Section 2 of this Part or national and international standards recognized by the Register.

Retests aiming to check mechanical properties shall be carried out in compliance with **1.3.5.3**.

During retests those characteristics shall be determined, for which negative results were obtained. In case of negative results of intergranular corrosion tests and retests for determination of mechanical properties obtained even for one specimen, the blanks shall be subjected to repeated heat treatment and submitted for tests as new ones.

Not more than three complete heat treatments are allowed.

3.16.1.9 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of **1.4**.

Every semi-finished product of stainless steel shall have the Register brand.

3.16.2 Rolled products.

3.16.2.1 These requirements apply to stainless steel plates, flats and sections with a thickness up to 50 mm as well as to hot-rolled and forged steel of round, square or rectangular section with a diameter or thickness up to 200 mm.

Table 3.16.1.5-2. **National stainless steels**

Steel class and mark	Content of elements, %								
	C	Si, max	Mn, max	Cr	Ni	Ti	Mo	S, max	P, max
1	2	3	4	5	6	7	8	9	10
Martensitic									
20Х13	0,16–0,25	0,8	0,8	12,0–14,0	–	–	–	0,025	0,030
30Х13	0,26–0,35	0,8	0,8	12,0–14,0	–	–	–	0,025	0,030
07Х16Н4Б	0,05–0,10	0,6	0,2–0,5	14,0–16,5	3,5–4,5	Nb 0,2–0,4	–	0,020	0,025
Martensite - ferritic									
14Х17Н2	0,11–0,17	0,8	0,8	16,0–18,0	1,5–2,5	–	–	0,025	0,030
Ferritic									
08Х17Т	max 0,08	0,8	0,8	16,0–18,0	–	5xC–0,8	–	0,025	0,030
Austenite - martensitic									
08Х17Н6Т	max 0,08	0,8	0,8	16,5–18,0	5,5–6,5	0,15–0,35	–	0,020	0,035
Austenitic									
08Х18Н10Т	max 0,08	0,8	2,0	17,0–19,0	9,0–11,0	5C–0,7	–	0,020	0,035
12Х18Н10Т	max 0,12	0,8	2,0	17,0–19,0	9,0–11,0	5C–0,8	–	0,020	0,035
10Х17Н13М3Т	max 0,10	0,8	2,0	16,0–18,0	12,0–14,0	5C–0,7	3,0–4,0	0,020	0,035
03Х17Н14М3	max 0,03	max 0,4	1,0–2,0	16,8–18,3	13,5–15,0	–	2,2–2,8	0,020	0,030
Austenite - ferritic									
08Х22Н6Т	max 0,08	0,8	0,8	21,0–23,0	5,3–6,3	5C–0,65	–	0,025	0,035
08Х21Н6М2Т	max 0,08	0,8	0,8	20,0–22,0	5,5–6,5	0,20–0,40	1,8–2,5	0,025	0,035
03Х22Н6М2	max 0,03	max 0,4	1,0–2,0	21,0–23,0	5,5–6,5	–	1,8–2,5	0,020	0,035

Table 3.16.1.8.1. **Types of semi-finished products of stainless steel tests**

Characteristics to be determined	Steel class							
	M-1	MF-2	F-3	AM-4	A-5	A-6	A-7	AF-8
Mechanical properties at 20°C:								
tensile strength, R_m	+	+	+	+	+	+	+	+
yield stress, $R_{p0,2}$	+	+	+	+	+	+	+	+
elongation, A_5	+	+	+	+	+	+	+	+
reduction in area, Z	+	+	+	+	+	+	+	+
Same at operating temperature	+[1]	+[1]	+[1]	+[1]	+[1]	+[1]	+[1]	+[1]
Impact toughness at +20°C, $KCV^{+20°}$	+	+	+	+	–	–	–	+
Impact toughness at a temperature below, KCV	+[1]	+[1]	–	+[1]	+[1]	+[1]	+[1]	+[1]
Impact energy at a temperature below, KV	–	–	–	–	+[1]	+[1]	+[1]	+
Susceptibility to intergranular corrosion	+[2]	+	+	+	+	+	+	+
Macrostructure examination	+	+	+	+	+	+	+	+
α- phase examination	–	–	–	–	+[1]	+[1]	+[1]	–
Grain size control	–	–	+	+[1]	+[1]	+[1]	+[1]	+[1]
Process tests	+[1]	+[1]	+[1]	+[1]	+[1]	+[1]	+[1]	+[1]
Non-destructive testing	+	+	+	+	+	+	+	+
Control of non-metallic inclusion content	+[1]	+[1]	+[1]	+[1]	+[1]	+[1]	+[1]	+[1]

Determination or confirmation of brittleness critical temperature	+[1]	+[1]	+[1]	+[1]	–	–	–	–
[1] When specified in the approved documentation. [2] When specified in the approved documentation 07Х16Н4Б								

3.16.2.2 Mechanical properties of steel at 20 8C shall not be worse than given in Table 3.16.2.2.

Table 3.16.2.2 **Mechanical properties of stainless steel rolled products**

Steel class	Tensile strength R_m, MPa, min	Yield stress $R_{p0,2}$, MPa, min	Elongation A_5, %, min
M-1	650	440	16
	850	735	13
MF-2	690	540	12
F-3	440	–	18
A-5	440	175	45
	490	195	35
A-6	440	185	40
	510	200	35
A-7	650	300	35
AF-8	580	340	20
	650	450	25
	760	550	15

In determining mechanical properties of rolled products (bars) using transverse specimens, the requirements may be reduced in accordance with the provisions of national or international standards.

3.16.2.3 Scope of tests.

The number of samples and batch size for rolled products shall be determined in the following way: for steel plates and wide flats (≥ 600 mm) more than 20 mm in thickness, more than 10 m long and more than 5 tons in mass samples are taken from both ends of each rolled product. In other cases, a sample is taken from one end of the rolled product;

for steel plates and wide flats (≥ 600 mm) less than 20 mm in thickness, samples are taken from one end of the plate of the batch containing not more than 20 plates;

for rolled steel, samples are taken from both ends of each roll;

for steel plates and sections, samples are taken from one end of one semi-finished product of the batch containing not more than 50 pieces, having a mass not more than 5 t.

Plates that vary in thickness by not more than 5 mm may be combined in one batch.

As a rule, the following specimens shall be prepared from each sample of steel plates, wide flats and bars:

one specimen for tensile test;

two specimens for impact toughness test;

one set of specimens (at least two pieces) for austenitic steels, two sets of specimens (at least four pieces) for austenitic - ferritic and austenitic - martensitic steels, one of which is a check specimen, for intergranular corrosion tests;

at least one template for macrostructure control.

3.16.2.4 Inspection.

All the plates and rods of the batch shall undergo verification of the geometric dimensions. Rolled products shall not have any defects preventing them from use for intended applications. The absence of defects shall be the manufacturer's responsibility and may be proved by non-destructive testing.

Non-destructive testing shall be performed according to national standards.

Surface imperfections resulted from the manufacturing process used are permitted, provided they are within permissible limits, counting from the nominal thickness.

Defective areas may be welded in cases where the depth of the chipped areas after rectifying defects does not exceed 20 % of the nominal thickness of the billet, and the total chipped area does not exceed 2 % of the total area of the billet.

Where projections of welded areas coincide in thickness on both sides of the blank, the permissible chipped areas shall not exceed in total the depth permissible on one side the billet.

Welding, examination of welded areas and heat treatment (if necessary) shall be performed according to the manufacturer's documentation agreed with the surveyor to the Register with the following marking of welded areas in the Certificate.

3.16.3 Forgings.

3.16.3.1 These requirements apply to semi-finished products manufactured by forging and hot stamping.

3.16.3.2 Mechanical properties of forgings and stampings, to which intergranular corrosion requirements apply, shall not be lower than that given in Table 3.16.3.2-1.

Mechanical properties of forgings and stampings, to which intergranular corrosion requirements do not apply, shall meet the requirements of Table 3.16.3.2-2.

In the above tables mechanical properties determined on longitudinal specimens are given for semifinished products, the diameter (thickness) of which does not exceed 300 mm.

Mechanical properties of bigger forgings are specified by the manufacturer in accordance with the acting standards and subject to agreement with the Register.

Table 3.16.3.2-1. **Mechanical properties of stainless steel forgings and stampings, to which intergranular corrosion requirements apply**

Steel class	**Tensile strength R_m, MPa, min**	**Yield stress $R_{p0,2}$, MPa, min**	**Elongation A_5, %, min**
M-1	880	690	12
MF-2	690	540	12
AM-4	730	540	12
A-5	490	190	38
A-6	510	210	38
AF-8	590	340	17

Table 3.16.3.2-2. **Mechanical properties of stainless steel forgings and stampings to which intergranular corrosion requirements do not apply**

Steel class	**Tensile strength R_m, MPa, min**	**Yield stress $R_{p0,2}$, MPa, min**	**Elongation A_5, %, min**
M-1	650	440	13
MF-2	690	540	12
AM-4	730	630	10
	880	730	12

In determining mechanical properties of forgings using transverse, radial or tangential specimens the requirements for mechanical properties may be reduced in accordance with provisions of national and international standards or by values given in Table 3.16.3.2-3.

Table 3.16.3.2-3. **Permissible reduction of mechanical properties when using transverse, radial and tangential specimens, in %**

Mechanical properties	**Види зразків**			
	Transverse	Radial	Tangential specimens for ingots having diameter (thickness), mm	
			до 300	більше 300
Yield stress $R_{p0,2}$, MPa	10	10	5,0	5,0
Tensile strength R_m, MPa	10	10	5,0	5,0
Elongation A_5,%	50	35	25	30
Reduction in area Z, %	50	40	25	30
Impact toughness KCV, in J/cm^2	50	40	25	30

Notes: 1. For forgings of "ring" type with a diameter more than 1000 mm produced by drawing, the requirements for mechanical properties obtained in testing tangential specimens are based on the requirements for longitudinal specimens.

2. In any case impact toughness shall not be less than 30 J/cm^2 and elongation shall not be less than 9 %.

3.16.3.3 Scope of tests.

The number of samples and batch size of stainless steel forgings and stampings shall be determined as follows:

for forgings and stampings of 20 kg in mass or less - from one semi-finished product of the batch consisting of not more than 30 pieces. Samples are taken from one end of the semi-finished product;

for forgings and stampings having a mass from 20 to 1000 kg - from one semi-finished product of the batch consisting of not more than 10 pieces. Samples are taken from one end of the semi-finished product;

for forgings and stampings of more than 1000 kg in mass - from each forging.

Where a length is 3 m and more, from both ends of each forging.

Forgings made according to different drawings but close in shape and varying in section by not more than 25 % may be combined in one batch.

As a rule, the following specimens shall be prepared from each sample:

for tensile test - one specimen;

for impact toughness - two specimens;

for intergranular corrosion test - four specimens, two of which are check specimens;

for macrostructure control - at least one specimen.

3.16.3.4 Inspection.

All forgings and stampings of the batch are subject to inspection of a surface and dimensions. Absence of inadmissible defects shall be guaranteed by the manufacturer and may be proved by non-destructive testing, if specified by order specification.

Welding of defects is subject to special consideration by the Register in each particular case and is generally restricted to the rectification of the defects of minor nature and in areas of low working stresses.

The repairing technique and testing procedure are subject to the Register agreement.

After welding the location of all repairs and the results of inspection shall be shown in the drawing or sketch of the forging and annexed to the Register Certificate.

3.16.4 Pipes.

3.16.4.1 These requirements apply to hot- and cold-formed pipes of stainless steel.

3.16.4.2 Mechanical properties of pipes shall not be lower than that given in Table 3.16.4.2.

Table 3.16.4.2. **Mechanical properties of pipes**

Steel class	Tensile strength R_m, MPa, min	Yield stress $R_{p0,2}$, MPa, min	Elongation A_5, %, min
A-5	490	175	30
	549	186	35
A-6	490	185	30
	529	216	30
AF-8	580	200	20
	690	450	25
	760	550	15
	800	550	25

3.16.4.3 Scope of testing.

The size of the batch shall be determined as follows:

where the outside diameter is 76 mm and less - 300 pieces; where the outside diameter is over 76 mm - 200 pieces.

Samples are taken from one end of at least two pipes of the batch.

Unless expressly specified otherwise by the Register or standards, the following specimens shall be taken from each sample:

for tensile test -1 specimen;

for flattening or expansion of rings -1 specimen;

for flaring -1 specimen;

for intergranular corrosion test of pipes made of austenitic steel -1 set of specimens (at least 2 pieces);

for pipes of austenitic + ferritic pipes -2 sets of specimens (at least 4 pieces), one of which is a check set;

each pipe shall be subjected to a hydraulic pressure test and ultrasonic testing.

3.16.4.4 Inspection.

All pipes and tubes shall undergo external and internal examination of the surface. Absence of inadmissible defects shall be guaranteed by the the manufacturer and proved by non-destructive testing.

3.17 CLAD STEEL

3.17.1 General.

3.17.1.1 The present requirements cover steel plates of low-alloy metal coated with a thin layer of stainless steel on one or both sides and intended for tanks and vessels being subject to the Register technical supervision, as well as for ice strakes of icebreakers, arctic ice class ships, mobile offshore drilling units and fixed offshore platforms.

3.17.1.2 Clad steel shall be produced in accordance with international and national standards or works specifications. The Register representative carrying out the technical supervision at the manufacturer's of clad steel plates, which has no foundry for all the ingredients of clad steel, shall be provided with the Manufacturer's Certificates for billets. All ingredients shall meet the requirements of the relevant Chapters of this Part.

3.17.1.3 Hull structural rolled products of B to F Grades with a yield stress from 235 MPa to 690 MPa shall be used as base material of clad steel in accordance with the requirements of **3.2**, **3.5**, **3.13** and **3.14**.

The steel shall be selected in compliance with the structure function (refer to **1.2**, Part II "Hull" of these Rules and **1.5**, Part II "Hull" of the Rules for the Classification, Construction and Equipment of MODU/FOP) reasoning from the design service temperature of the material T_P, відповідальності елементу конструкції (спеціальні чи основні), товщини основного шару, вимог до Z-властивостей та умов навантаження. he function of a structural member (special or primary), the base material thickness, requirements for Z-properties and loading conditions

In cases not specified in Table 1.5.1.2, Part II "Hull" of the Rules for the Classification, Construction and Equipment of MODU/FOP the selection of the base material steel grade shall meet the requirements of **3.17.4.1.9** and **3.17.4.1.11**, **3.2** and **3.5** of this Part, as well as the requirements of **3.2**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP. The base metal shall be over 10 mm thick.

Austenitic or austenitic-ferritic stainless steels (classes A and AF) having a chemical composition and properties meeting the requirements of **3.16** shall be used as the cladding metal.

The use of other brands of corrosion-resistant materials as the cladding metal shall be approved by the Register as part of the submitted normative technical documentation of the product.

The nominal thickness of the cladding metal shall be not less than 2 mm.

The cladding metal shall be chosen considering the specific operational conditions.

3.17.1.4 Hot (pack) rolling, explosion welding, overlay rolling or a combination thereof may be used for plate cladding.

3.17.2 Chemical composition and mechanical properties.

3.17.2.1 The chemical composition and mechanical properties of the base metal shall meet the requirements of **3.2**, **3.5**, **3.13** and **3.14**.

Unless otherwise specified, sampling and the base metal testing shall be carried out in accordance with the requirements of the above chapters.

3.17.2.2 The chemical composition and mechanical properties of the cladding metal shall meet the requirements of **3.16**.

3.17.2.3 The use of clad steel for specific operational conditions shall be agreed in each particular case.

3.17.3 Condition of supply.

3.17.3.1 Plates with stainless steel cladding shall be supplied in as-rolled condition and may be heattreated to ensure the properties of the base metal. In this case the corrosion resistance of the cladding metal after heat treatment shall meet the requirements of **3.16**.

The type of heat treatment shall meet the requirements of standards and shall be approved by the Register at the initial survey of the manufacturer.

3.17.4 Scope of testing.

3.17.4.1 The scope of testing at the initial survey of the manufacturer shall be determined by the programme agreed with the Register.

The following types of tests may additionally be carried out:

tensile test on the full thickness clad plate test specimen;

bend test on the clad test specimens;

shear test on the cladding metal;

resistance of the cladding metal against intergranular corrosion;

test for determining the base material Z-properties;

test for determining the base material crack resistance.

3.17.4.1.1 Strength in tensile test on the full thickness clad plates.

The tensile test on the full thickness clad plate test specimens shall be performed for determining the tensile strength and yield stress of clad steel. With the total thickness of less than 20 mm the clad plate in tensile test shall meet the following requirement:

$$R \geq (R_o \cdot t_o + R_n \cdot t_n)/t \quad , \qquad (3.17.4.1.1)$$

where R — nominal value of tensile strength or yield stress of the clad plate, MPa;

R_o, R_n — nominal value of tensile strength R_m or yield stress $R_{0\,2}$ (σ_m, $\sigma_{0,2}$) for base metal and cladding metal, respectively, МПа;

t_o, t_n — nominal thickness of base material and cladding metal, respectively, mm;

t — nominal thickness of the clad plate, mm.

3.17.4.1.2 Determination of plybond strength.

The bend test on the clad test specimens shall be performed for the qualitative assessment of bond resistance of the base material and cladding metal. No separations of the cladding in bending shall be a performance criterion.

Three test specimens shall be taken from each plate end for bend test. One bend test shall be carried out with the cladding metal on the tensioned side and another with the cladding layer on the compressed side.

The third test specimen shall be subject to transverse bending with the cladding vertically oriented.

The procedure for test specimens' preparation and test performance shall comply with the manufacturer's documentation, national or international standards.

3.17.4.1.3 Shear test on the cladding metal. Two test specimens shall be taken from each plate end for shear testing. The specimen axis shall be transverse to the rolling direction. The test shall be performed according to requirements of the relevant national standard, ASTM 264 or DIN 50162.

The shear strength shall be at least 140 N/mm^2.

3.17.4.1.4 Resistance against intergranular corrosion.

The cladding metal shall be resistant to intergranular corrosion.

The corrosion resistance tests for clad steel shall be carried out in compliance with a national or international standard. In any case the test procedure shall be preliminary agreed with the Register.

The resistance against intergranular corrosion shall be checked for each metal heat used for cladding.

3.17.4.1.5 Z-properties.

Z-properties shall be determined in clad steel with the base material 20 mm to 100 mm thick and a yield stress of up to 690 MPa inclusive.

Prior to test specimens' preparation for determining the Z-properties, the cladding metal shall be completely removed.

The Z-properties criterion is the value of the reduction in cross-sectional area in testing a cylindrical test specimen for axial tension to failure. The specimen shall be cut out so that its longitudinal axis is perpendicular to the plate plane and its center is the center of the base metal thickness.

Note: Selecting the test specimen standard size, two key factors shall be considered:

parallel length diameter d;

repetition factor l/d or the parallel length l to diameter d ratio.

Minimum values: d_{min}=4 mm; l_{min}=1,5d.

The use of dmin and lmin allows to prepare a solid specimen of 4 mm in diameter without welded extensions at the metal thickness within 18 mm to 27 mm.

The solid specimen of 6 mm in diameter may be used for the metal thickness within 27 mm to 45 mm, and of 10 mm in diameter, over 45 mm.

For MODU and FOP special purpose structures the average value of the relative reduction of area Z_z of three test specimens taken from each plate in the through base material thickness direction of a clad plate shall comprise at least 35 % with one test result allowed below 35 %, but not less than 25 %.

For MODU and FOP primary structures the average value of the reduction in area Z_z of three tested specimens shall comprise at least 25 % with one test result allowed below 25 %, but not less than 15 %.

Z-steel for the clad steel base material shall comply with the requirements of 3.14 for Z35 and Z25 grade steels. The procedure for determining the clad steel plybond strength shall be approved by the Register.

If the value Z_z obtained is below the specified minimum value or if one individual test result is less than the specified one, additional tests on three new test specimens shall be carried out. The average of the results of the six tests shall not be less than the specified value. No individual result from the three new series shall be less than the specified minimum value.

3.17.4.1.6 The crack resistance of the base material shall be defined in tests for determining the following parameters:

.1 ductile-brittle transition temperature T_{kb};

.2 nil-ductility temperature NTD.

The above temperatures shall be determined in accordance with Section **2**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP.

3.17.4.1.7 Tests for determining temperature T_{kb}.

The temperature T_{kb} is the temperature of a ductile-brittle transition and is defined by a 70 % fibrous component in the fracture of a full thickness test specimen. The tests performed for determining T_{kb} allow to evaluate the temperature of brittle crack stopping T_{br} in a full thickness metal (from 14 to 100 mm) provided that:

$$T_{br} \geq 0{,}9\ T_{kb} - 10\ °C.$$

Test specimens for determining the T_{kb} value for clad steel shall be prepared from the full thickness base material after the removal of cladding and the part of the base material no more than 0,5 mm thick on the cladding side.

The procedure for tests performance shall be agreed with the Register.

Samples for test specimen preparation for determining T_{kb} shall be taken in areas which are the nearest to the areas of sampling for determining mechanical properties of the base metal.

The test specimens' thickness shall correspond to the base material thickness after the removal of cladding with other dimensions being in the optimum relationship with thickness:

test specimen height: $W = 3\delta \pm 3$mm;

length: $L = 4W + \delta = 13\delta \pm 10$mm;

notch depth:

$\alpha = ⅓\ W = \delta \pm 1$mm;

distance between supports at three-point bending:

$l = 4\ W = 12\delta \pm 10$mm;

notch radius:

$R = 3^{+0,5}$mm at metal thickness of up to 32 mm inclusive,

$R = 3^{+2}$mm at metal thickness of over 32 mm;

notch width is a technological quantity if the notch is made with gas cutting.

The value of the temperature T_{kb} obtained shall be confirmed by testing of three test specimens. If the fracture contains 70±5% of the fibrous component in two of three cases, the given temperature is assumed as T_{kb}.

3.17.4.1.8 Drop weight test for determining nil-ductility temperature NTD.

The NTD is the temperature at which standard test specimens with a brittle notched weld deposit fail in an impact test.

The specimen deflection in testing shall be bounded with a stop and be in compliance with ASTM E208.

The test specimens for determining the clad steel NTD shall be prepared from the base metal. In this case the tensioned surface of the specimen shall coincide with the base material surface, which is opposite to the cladding, and shall remain in the initial condition.

The procedure for specimens preparation, specimen types, equipment, jigs and fixtures, instrumentation and correctness conditions for the NTD values obtained shall meet the requirements of **2.3**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP. The procedure for drop weight test for NTD determining shall be agreed with the Register.

3.17.4.1.9 Requirements for clad steel base metal for temperatures T_{kb} and NTD.

For the special members of ice strake structures directly exposed to dynamic ice or seismic loads of which the material shall effectively stop a brittle crack at the design service temperature T_d, the conditions below shall be observed: for temperature T_{kb}:

$T_{kb} \leq 1{,}1T_p + 10°C$ − for metal thickness of 14 mm to 100 mm;

for temperature NTD:

NDT $\leq T_p$− for thickness $t \leq 15$мм;

NDT $\leq T_p$-10°C − for thickness $15 < t \leq 20$ mm;

NDT$\leq T_p$-20°C− for thickness $20 < t \leq 30$ mm;

NDT$\leq T_p$-25°C− for thickness $30 < t \leq 40$ mm.

3.17.4.1.10 For the special members of ice strake structures not covered by the requirements of **3.17.4.1.9** and for the primary members exposed to cyclic ice loads, wind-wave and seismic loads, the condition below shall only be observed for NTD:

NDT ≤ T_p− for thickness $t \le$ 15mm;

NDT≤T_p-10°C − for thickness 15 < t ≤ 20mm.

3.17.4.1.11 Steels with crack resistance properties specified. The clad steel for structures used at low environmental temperatures of down to -50°C may be tested for determining a crack resistance parameter CTOD being the critical value of a crack opening displacement, in mm, and associated with a certain kind of crack extension at static loading.

The test for determining the CTOD shall be performed on the test specimens cut from the base metal after the removal of cladding and the part of the base metal not more than 0,5 mm thick.

The CTOD test shall be carried out according to the procedure agreed with the Register according to the requirements of **2.2**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP or in international standards, e.g. BS 7448, Part **2**.

The requirements for the CTOD values for clad steel base metal for special and primary structures shall not be lower than those in Tables 3.17.4.1.11-1 and 3.17.4.1.11-2.

Table 3.17.4.1.11-1 **CTOD values for clad steel base metal depending on steel thickness and strength level for special structures members**

Thickness, mm, not more than	Strength level (minimum yield stress required, MPa)									
	*	315	355	390	420	460	500	550	620	690
20	0,08	0,08	0,10	0,10	0,10	0,10	0,15	0,15	0,15	0,20
30	0,08	0,10	0,15	0,15	0,15	0,20	0,20	0,20	0,25	0,25
40	0,15	0,15	0,20	0,20	0,20	0,25	0,25	0,30	0,35	0,35
50	0,20	0,20	0,20	0,25	0,25	0,30	0,30	0,35	0,40	0,45
* Normal strength level steel										

Table 3.17.4.1.11-2 **CTOD values for clad steel base metal depending on steel thickness and strength level for primary structures members, as well as for HAZ base metal of special structures members**

Thickness, mm, not more than	Strength level (minimum yield stress required, MPa)									
	*	315	355	390	420	460	500	550	620	690
20	0,08	0,08	0,08	0,08	0,10	0,10	0,10	0,10	0,10	0,15
30	0,08	0,10	0,10	0,10	0,10	0,10	0,15	0,15	0,20	0,20
40	0,10	0,10	0,10	0,15	0,15	0,15	0,20	0,20	0,20	0,25
50	0,10	0,15	0,15	0,20	0,20	0,20	0,20	0,25	0,25	0,30
* Normal strength level steel										

3.17.4.1.12 Additional tests of welded joints for ice strake structures.

3.17.4.1.12.1 The requirements cover welded joints of the ice strake members of MODU and FOP special and primary structures made of clad steel and intended for operation at low temperatures and exposured to dynamic and seismic loads.

3.17.4.1.12.2 Welded joints of clad steel shall be made and checked in compliance with the general requirements of **1.3**, Part XIV "Welding" of these Rules, as well as of **2.1** to **2.5**, **2.6.1.4** and **2.9.3**, Part XII "Welding" of the Rules for the Classification, Construction and Equipment of MODU/FOP.

The ice strake structures of clad steel shall be welded with the use of the Register-approved welding consumables produced at the Register-recognized manufacturers.

The welding consumables for the base material shall meet the requirements of **4.1**, **4.2**, **4.5** and **4.6**, and for the cladding metal, the requirements of **4.8**, Part XIV "Welding" of these Rules.

3.17.4.1.12.3 The welded joints of clad steel, which comply with **3.17.4.1.12.1** and **3.17.4.1.12.2**, may be additionally tested for determining the crack resistance parameter CTOD and the resistance against intergranular corrosion.

3.17.4.1.12.4 Samples for preparing test specimens for CTOD tests shall be taken from the welded butt joints of clad steel. For this purpose, the cladding metal, including the one deposited on the weld, shall be removed after welding.

In order to determine the crack resistance of the HAZ, the bevel welding (double-bevel or single-bevel groove) is recommended which allows to arrange a crack front in the proper layer of the HAZ.

The welding procedure shall be approved by the Register**.**

The CTOD tests of the test specimens prepared in this way shall be carried out in compliance with the requirements of **2.2**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of MODU/FOP.

3.17.4.1.12.5 The requirements for the CTOD values of the heat-affected zone metal for special structures members depending on the thickness and strength level of the clad steel base metal shall be not less than those in Table 3.17.4.1.11-2.

Note: The tests of clad steel welded joints for determining the crack resistance parameter CTOD to the extent of the requirements of **3.17.4.1.12.3**, **3.17.4.1.12.4** and **3.17.4.1.12.5** may be ignored, and the results obtained on the base metal welded joints may be considered in certification.

3.17.4.1.12.6 The test specimens for checking the clad steel welded joints resistance against intergranular corrosion shall be cut from the cladding metal of the welded butt joints in such a way that the cladding HAZ is in the middle of the specimen in the form of a plate dimensioned 2x2x680 mm.

The accelerated tests of these specimens for the resistance against intergranular corrosion shall be performed in the same manner as specified in **3.17.4.1.4** for the cladding metal, and then they shall be bent through the angle meeting to the national or international standard requirements.

The presence of cracks on the tensioned side of the specimen evidences the tendency to intergranular corrosion while the cracks absence shows the intergranular corrosion resistance.

3.17.4.1.12.7 The welded joints resistance against intergranular corrosion shall be checked for each welding process for each batch of clad plates which have the cladding from one batch and are made in the same manner.

3.17.4.1.12.8 The procedure for testing welded joints for the resistance against intergranular corrosion shall be previously agreed with the Register.

3.17.4.2 The tests scope during steelmaking at the Register-recognized manufacturer shall be determined in accordance with the Register-approved documentation considering the additional contract requirements, if any.

3.17.4.2.1 The tests scope for the base metal of normal and higher strength steels shall comply with the requirements of **3.2**, and of higher strength Grade F steel, with the requirements of 3.5, of high strength steel, with the requirements of **3.13** and of steel with specified through thickness properties, with the requirements of **3.14**.

3.17.4.2.2 Besides the above, testing can be performed to the following extent:

determination of plybond strength in bending three test specimens. One specimen is bent with the cladding on the tensioned side and another, with the cladding on the compressed side. The third one shall be tested for transverse bending with the cladding vertically oriented;

determination of shear strength of the cladding;

determination of the cladding metal resistance against intergranular corrosion according to **3.17.4.1.4**;

all the plates are subject to the ultrasonic testing of the continuity of the cladding and base metal adhesion over the entire surface of the plate.

The continuity characteristics and the ultrasonic testing method shall comply with the requirements of the manufacturer's documentation, national or international standards.

The test scope shall be agreed with the Register before the commencement of the technical supervision at the manufacturer.

3.17.5 Inspection.

3.17.5.1 All plates are subject to surface inspection. The manufacturer shall ensure the absence of unacceptable defects. The quality of the plate surface shall be checked by surveyor to the Register after the manufacturer's checking.

3.17.5.2 The cladding metal surface condition shall meet the requirements of **3.16.2.4**. No scale, annealing colors and other defects which may affect the chemical durability and the machinability of clad plates are acceptable.

The surface defects caused by a method of manufacturing are allowed if their depth is within the minus deviations of the cladding metal thickness specified in Table 3.17.5.7.

3.17.5.3 The cladding metal surface defects being within a tolerance for its thickness shall be ground in such a way that a smooth transition from a restored area to the surface of the rest of the metal is ensured.

The residual cladding shall have a thickness not less than the nominal one considering the tolerance for a lower dimension in Table 3.17.5.7.

3.17.5.4 The surface defects with the cladding thickness after grinding less than the permissible one shall be eliminated by welding provided the total area of all rebuilt defects does not exceed 5 % of the cladding area.

All the plates are subject to ultrasonic testing.

3.17.5.5 If, after grinding of the defect, the remaining thickness of the cladding is less than half of the guaranteed nominal thickness, it is necessary to replace the cladding by tapering and to rebuild the whole of the cladding metal by welding.

3.17.5.6 The quality of the base metal and cladding metal adhesion shall be determined by ultrasonic testing which shall be specified in the manufacturer's documentation.

Continuity defects which exceed the values specified in the technical conditions, specification or relevant standard shall be repaired or eliminated. The repair procedure by rebuilding shall be agreed with the Register considering the following conditions.

3.17.5.6.1 The rebuilding shall be performed by qualified welders using the materials and methods approved by the Register.

3.17.5.6.2 All buildings-up shall be free from cracks, lacks of fusion, undercuts, slags and other defects which can degrade cladding quality.

If the welding process is associated with flashing of the base metal, two layers of cladding metal as a minimum shall be built up on it.

3.17.5.6.3 Following welding, the rectified defect shall be ground flush with the cladding surface. After final repairs the plates shall be submitted to surveyor to the Register.

The quality of defects elimination shall be proved by non-destructive testing.

3.17.5.6.4 The manufacturer shall submit to the surveyor a report on each rectification by rebuilding wherein the dimensions and location of defects, procedure for repairs by rebuilding, type of heat treatment if required, and the results of checking the defects elimination quality shall be specified.

3.17.5.6.5 Rectification of the base material surface defects by welding is not allowed.

3.17.5.7 Limiting deviations of a cladding thickness, unless the more strict tolerances are specified in an order, shall correspond to those given in Table 3.17.5.7.

The cladding thickness shall be measured at a distance of not less than 10 mm from a plate edge.

Table 3.17.5.7 **Limiting deviations of cladding metal thickness**

Nominal thickness, mm	Permissible deviation, mm
≥ 2,0 < 3,0	± 0,20
≥ 3,0 < 3,5	± 0,30
≥ 3,5 < 4,0	± 0,35
≥ 4,0 < 5,0	± 0,40
≥ 5,0	± 0,45

3.17.6 Marking shall be carried out according to the requirements of **1.4**.

3.18 NORMAL AND HIGHER STRENGTH CORROSION-RESISTANT STEELS FOR CARGO OIL TANKS

3.18.1 Scope of application.

3.18.1.1 These requirements apply to normal and higher strength corrosion-resistant steels when such steel is used as the alternative means of corrosion protection for cargo oil tanks as specified in regulation II-1/3-11 of SOLAS-74 (IMO resolution MSC.289(87) "Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers").

3.18.1.2 The requirements are primarily intended to apply to steel products of the following types and thickness:

steel plates and wide flats:

all grades: up to 50 mm in thickness;

sections and bars:

all grades: up to 50 mm in thickness.

3.18.1.3 Normal and higher strength corrosion-resistant steels as defined within these requirements are steels whose corrosion resistance performance in the bottom or top of the internal cargo oil tank is tested and approved to satisfy the requirements in IMO resolution MSC.289(87) in addition to other relevant requirements for structural steel, strength and construction.

It is not intended that such steels be used for corrosion-resistant applications in other ship areas that are outside of those specified in regulation II-1/3-11 of SOLAS-74 (IMO resolution MSC.289(87)).

3.18.1.4 Since corrosion-resistant steels described in this Chapter are similar to the ship steels as specified in **3.2**, the basic requirements of **3.2** apply to these steels except where modified by this Chapter.

3.18.1.5 The weldability of corrosion-resistant steels is similar to those given in **3.2**, therefore welding requirements specified in Sections **4** and **6**, Part XIV "Welding" of the Rules

3.18.2 Approval.

3.18.2.1 All materials shall be manufactured at works recognised by the Register (having Recognition Certificate for Manufacturer in accordance with **1.3**.

3.18.2.2 In addition to the tests carried out for Recognition Certificate for Manufacturer as specified in **2.1**, corrosion tests shall be carried out in accordance with **3.18.17**.

In the Recognition Certificate for Manufacturer a special mark may be entered for application in one of the following areas of a cargo oil tank:

.1 lower surface of strength deck and surrounding structures;

.2 upper surface of inner bottom plating and surrounding structures;

.3 both strength deck and inner bottom plating.

3.18.2.3 It is the manufacturer's responsibility to assure that effective process and production controls in operation are adhered to within the manufacturing specifications agreed upon with the Register.

If the process or production controls are changed in any way, or any product fails to meet specifications, the manufacturer shall issue a report explaining the reasons, and, in the instance of product, which fails to meet specifications, the measures to prevent recurrence. The complete report shall be submitted to the surveyor to the Register along with such additional information as the surveyor may require. Each affected piece shall be tested to the satisfaction of the surveyor to the Register.

The frequency of testing for subsequent products is at the discretion of the Register with regard to development and performance of the particular arrangements by manufacturer.

3.18.3 Methods of manufacture.

3.18.3.1 Methods of manufacture, deoxidation practice and rolling practice shall be in accordance with **3.2**.

3.18.4 Chemical composition.

3.18.4.1 The chemical composition of samples taken from each ladle of each cast shall be determined by the manufacturer in an adequately equipped and competently staffed laboratory and shall be in accordance with the requirements of **3.2**.

3.18.4.2 The manufacturer will establish a relationship of all the chemical elements, which affect the corrosion resistance. The chemical elements added or controlled to achieve this shall be specifically verified for acceptance. Verification shall be based on the ladle analysis of the steel.

3.18.4.3 The manufacturer's declared analysis will be accepted subject to periodic random checks.

3.18.4.4 The carbon equivalent shall be in accordance with **3.2**.

3.18.5 Condition of supply.

3.18.5.1 All materials shall be supplied in one of the supply conditions specified in **3.2**.

3.18.6 Mechanical properties.

3.18.6.1 Tensile testing and Charpy V-notch impact testing shall be carried out in accordance with **3.2**.

3.18.7 Freedom from defects.

3.18.7.1 The steel shall be reasonably free from segregations and non-metallic inclusions. The finished material shall have a workmanlike finish and shall be free from internal and surface defects prejudicial to the use of the material for the intended application.

3.18.7.2 The acceptance criteria for surface finish and procedures for the repair of defects, as detailed in **3.2**, shall be observed.

3.18.8 Tolerances.

3.18.8.1 Unless otherwise specified, the thickness tolerances in 3.2 are applicable.

3.18.9 Identification of materials.

3.18.9.1 The steelmaker shall adopt a system for the identification of ingots, slabs and finished products, which will enable the material to be traced to its original cast.

3.18.9.2 The surveyor to the Register shall be given full facilities for so tracing the material when required.

3.18.10 Testing and inspection.

3.18.10.1 Facilities for inspection.

3.18.10.1.1 The manufacturer shall afford the surveyor to the Register all necessary facilities and access to all relevant parts of the works to enable him to verify that the approved process is adhered to, for the selection of test materials, and the witnessing of tests, as required by the Rules, and for verifying the accuracy of the testing equipment.

3.18.10.2 Testing procedures.

3.18.10.2.1 The prescribed tests and inspections shall be carried out at the place of manufacture before dispatch. The test specimens and procedures shall be in accordance with Section **2**. All the test specimens shall be selected, stamped and marked by the surveyor to the Register and tested in his presence, unless otherwise specified.

3.18.10.3 Through thickness tensile tests.

3.18.10.3.1 If plates and wide flats with thickness of 15 mm and over are ordered with through thickness properties, the through thickness tensile test in accordance with 2.2.2.7 shall be carried out.

3.18.10.4 Ultrasonic testing.

3.18.10.4.1 If plates and wide flats are ordered with ultrasonic testing, this shall be made in accordance with the standards recognized by the Register. 3.18.10.5 Surface inspection and dimensions. 3.18.10.5.1 Surface inspection and verification of dimensions are the responsibility of the steel maker. The acceptance by the surveyor to the Register shall not absolve the steel maker from this responsibility.

3.18.11 Test material.

3.18.11.1 Sampling and preparation of test samples shall be in accordance with **3.2**.

3.18.12 Test specimens.

3.18.12.1 Mechanical test specimens.

3.18.12.1.1 The dimensions, orientation and location of the tensile and Charpy V-notch test specimens within the test samples shall be in accordance with Section **2** and **3.2**.

3.18.13 Scope of testing.

3.18.13.1 Scope of testing and the corresponding number of tensile and Charpy V-notch impact test specimens shall be in accordance with Section **2** и **3.2**.

3.18.14 Retest procedures.

3.18.14.1 Retest procedures shall be in accordance with **1.3.2**.

3.18.15 Marking.

3.18.15.1 Every finished product shall be clearly marked by the maker in at least one place with the Register brand and the following particulars:

.1 unified identification mark for the grade of steel (e.g. A36);

.2 steel plates that have complied with the requirements of the Rules shall be marked with a designation by adding a corrosion designation to the unified identification mark for the grade of steel.

Example of designation: A36 RCB;

.3 the corrosion resistant steel shall be designated according to its area of application as follows:

lower surface of strength deck and surrounding structures – RCU;

upper surface of inner bottom plating and surrounding structures – RCB;

both strength deck and inner bottom plating – RCW;

.4 steel supplied in the thermo-mechanically controlled process condition shall have the letters "TM" added after the identification mark but before the corrosion designation (e.g. E36 TM RCU Z35);

.5 name or initials to identify the steelworks;

.6 cast or other number to identify the piece;

.7 if required by the purchaser, his order number or other identification marks.

3.18.15.2 The above particulars, but excluding the manufacturer's name or trade marks, where this is embossed on finished products shall be encircled with paint or otherwise marked so as to be clearly legible.

3.18.15.3 Where a number of light materials are securely fastened together in bundles the manufacturer may mark only the top piece of each bundle, or alternatively, a firmly fastened durable label containing the marking may be attached to each bundle.

3.18.15.4 In the event that any material bearing the Register marking fails to comply with the test requirements, the marking shall be unmistakably defaced by the manufacturer.

3.18.16 Documentation.

3.18.16.1 Register and Manufacturer's Certificate shall be thoroughly verified before the material application.

3.18.16.2 The number of copies required shall be specified by the Register.

3.18.16.3 The documents shall be a submitted in either electronic or paper format.

3.18.16.4 Separate submission of documents for each grade of steel is permitted.

3.18.16.5 The document (Register and Manufacturer's Certificate) shall contain, in addition to the description, dimensions, etc., of the material, at least the following particulars as a minimum:

.1 purchaser's order number and if known the hull number, for which the material is intended;

.2 identification of the cast and product, including, where appropriate, the test specimen number;

.3 identification of the steelworks;

.4 identification of the grade of steel and the manufacturer's brand name;

.5 ladle analysis (for chemical elements specified in **3.2**);

.6 if the steel is approved in accordance with **3.4.2**, the weight percentage of each chemical element added or intentionally controlled for improving corrosion resistance;

.7 condition of supply when other than as rolled i.e. normalised, controlled rolled or thermomechanically rolled;

.8 results of mechanical tests.

3.18.16.6 Before the Certificate is issued, the manufacturer is required to furnish the surveyor to the Register with a written declaration stating that the material has been made by an approved process and that it has been subjected to and has withstood satisfactorily the required tests in the presence of the surveyor to the Register. The Register name shall appear on the Manufacturer's Certificate.

The following form of declaration will be accepted if stamped or printed on each test certificate or shipping statement with the name of the steelworks and initialled for the makers by an authorized official:

"We hereby certify that the material has been made by an approved process and has been satisfactorily tested in accordance with the Register Rules".

3.18.16.7 In the case of electronic certification the Register shall agree upon a procedure with the steel mill to ensure the signing of the issued certificate by the surveyor to the Register.

3.18.17 Additional approval procedure for corrosion-resistant steel.

3.18.17.1 Scope.

3.18.17.1.1 Recognition by the Register (obtaining by manufacturer of Recognition Certificate for Manufacturer) and approval of corrosion-resistant steel shall be carried out in accordance with **1.3** together with the additional requirements for corrosion testing specified in this Part.

3.18.17.1.2 The corrosion tests and acceptance criteria shall be in accordance with the Appendix of the Annex to Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers (IMO resolution MSC.289(87)).

3.18.17.2 Application for approval.

3.18.17.2.1 The manufacturer shall submit to the Register a request for approval, which shall include the following:

.1 corrosion test plan and details of equipment and test environments;

.2 technical data related to product assessment criteria for confirming corrosion resistance;

.3 the technical background explaining how the variation in added and controlled elements improves corrosion resistance;

.4 the grades, the brand name and maximum thickness of corrosion-resistant steel to be approved. Designations for corrosion-resistant steels are given in Table 3.18.17.2.1;

.5 the welding processes and the brand name of the welding consumables to be used for approval.

***Table 3.18.17.2.1*. Designations for corrosion-resistant steels**

Type of steel	Location where steel is effective	Corrosion-resistance designation
Rolled steel for hull	For lower surface of strength deck and surrounding structures (ullage space)	RCU
	For upper surface of inner bottom plating and surrounding structures	RCB
	For both strength deck and inner bottom plating	RCW

3.18.17.3 Approval of test program.

3.18.17.3.1 The test program submitted by the manufacturer shall be reviewed and agreed with the Register. Approved program returns to the manufacturer for acceptance.

Tests that need to be witnessed by the surveyor to the Register shall be identified.

3.18.17.3.2 Method for selection of test samples shall satisfy the following.

3.18.17.3.2.1 The numbers of test samples shall be in accordance with the requirements of the Appendix of the Annex to Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers (IMO resolution MSC.289(87)).

3.18.17.3.2.2 The number of casts and test samples selected shall be sufficient to make it possible to confirm the validity of interaction effects and/or the control range (upper limit, lower limit) of the elements, which are added or intentionally controlled, for improving the corrosion resistance. Where agreed, this may be supported with data submitted by the manufacturer.

3.18.17.3.2.3 Additional tests may be required by the Register when reviewing the test program in accordance with **3.2.2**.

3.18.17.3.3 In addition to **3.2**, the Register may require additional tests in the following cases:

.1 when the Register determines that the control range is set by the theoretical analysis of each element based on existing data, the number of corrosion resistance tests conducted in accordance with the Appendix of the Annex to Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers (IMO resolution MSC.289(87)) is too few to adequately confirm the validity of the control range of chemical composition;

.2 when the Register determines that the data of the corrosion resistance test result obtained for setting the control range of chemical composition varies too widely;

.3 when the Register determines that the validity of the corrosion resistance test result for setting the control range of chemical composition is insufficient, or has some flaws;

.4 when the surveyor to the Register has not attended the corrosion resistance tests for setting the control range of chemical composition, and the Register determines that additional testing is necessary in order to confirm the validity of the test result data; and

.5 when the Register determines that it is necessary, for reasons other than cases in **3.18.17.3.3.1** ÷ **3.18.17.3.3.4**.

3.18.17.3.4 The chemical composition of the corrosion-resistant steel shall be within the range specified for rolled steel for hull. Elements to be added for improving the corrosion resistance and for which content is not specified shall be generally within 1 % in total.

3.18.17.4 Carrying out the approval test.

3.18.17.4.1 The manufacturer shall carry out the approval test for corrosion-resistant steel and for obtaining a Recognition Certificate for Manufacturer in accordance with the approved test program.

3.18.17.5 Attendance of the surveyor to the Register for test.

3.18.17.5.1 The surveyor to the Register shall be present, as a rule, when the test samples for the approval test are being identified and for approval tests (refer also to **3.1**).

3.18.17.6 Test results.

3.18.17.6.1 After completion of the approval test for corrosion-resistant steel and for obtaining a Recognition Certificate for Manufacturer, the manufacturer shall produce the report of the approval test and submit it to the Register.

3.18.17.6.2 The Register will give approval for corrosion-resistant steel and issue a Recognition Certificate for Manufacturer where approval tests are considered by the Register to have given satisfactory results based on the data submitted in accordance with this Section.

3.18.17.6.3 The Recognition Certificate for Manufacturer shall contain the manufacturer's name, the period of validity of the Certificate, the grades and thickness of the steel approved, welding methods and welding consumables approved.

3.18.17.7 Acceptance criteria for results of corrosion resistance tests of welded joint.

3.18.17.7.1 The results shall be assessed by the Register in accordance with the acceptance criteria specified in the Appendix of the Annex to Performance Standard for Alternative Means of Corrosion Protection for Cargo Oil Tanks of Crude Oil Tankers (IMO resolution MSC.289(87)).

3.19 APPLICATION OF YP47 STEEL PLATES

3.19.1 Scope of application.

3.19.1.1 General.

3.19.1.1.1 These requirements apply to container carriers incorporating extremely thick steel plates in accordance with **3.19.1.2.1**.

3.19.1.1.2 This Section gives the basic concepts for application of YP47 steel plates to longitudinal structural members in the upper deck region of container carriers (such as hatch side coaming, hatch coaming top and the attached longitudinals). The Section contains the definition of YP47 steel plates, as well as the requirements for tests, survey and application of welding consumables and approval of welding procedure. Application of YP47 steel plate for other hull structures shall be approved by the Register.

3.19.1.1.3 Unless otherwise specified in the Section, the requirements of 3.2 shall be applied to YP47 steel plates. In case of the required use of YP47 steel regulated by the Section, its crack resistance shall comply with **3.19.2.3.3** of this Section.

3.19.1.1.4 YP47 steel plates mean the steel plates of specified minimum yield stress of 460 MPa. The scope of application is defined under **3.19.1.2** and **3.19.1.3**.

3.19.1.2 Thickness

3.19.1.2.1 This Section gives the requirements for steel plates with thickness of over 50 mm and not greater than 100 mm inclusively, used for manufacture of the hatch coamings and upper deck structural components of the container ships.

3.19.1.2.2 The properties of YP47 steel plates shall be approved by the Register.

3.19.1.3 Application.

3.19.1.3.1 In the case that YP47 steel plates are used for longitudinal structural members in the upper deck region (such as hatch side coaming and hatch coaming top and their attached longitudinals), the grade of YP47 steel plates shall be EH47 specified hereinafter.

3.19.2 General.

3.19.2.1 Hull structures.

3.19.2.1.1 Material factor of high tensile steel *K*.

3.19.2.1.1.1 Material factor of high tensile steel *K* used for assessment of hull girder strength shall be taken 0,62. The *K* factor values for YP36 and YP40 steels are specified in **1.1.4.3**, Part II "Hull".

3.19.2.1.2 Fatigue assessment.

3.19.2.1.1 Fatigue assessment on the longitudinal structural members shall be performed in accordance with the Register procedure.

3.19.2.1.3 Details of construction design.

3.19.2.1.3.1 Special consideration shall be paid to the details of constructions of structural members where YP47 steel plates are applied such as connections between outfitting and hull structures. Connections shall be in accordance with the documents approved by the Register.

3.19.2.2 Material specifications. **3.19.2.2.1** Material specifications for YP47 steel plates are given in Tables 3.19.2.2.1-1 and 3.19.2.2.1-2.

The tests shall be conducted in compliance with **3.2**.

3.19.2.3 Manufacturing approval test.

3.19.2.3.1 General.

Approval test items, test methods and acceptance criteria not specified in this Chapter shall be in compliance with **1.3**.

3.19.2.3.2 Range of approval.

3.19.2.3.2.1 One test product with the maximum thickness to be approved (to obtain a Recognition Certificate for Manufacturer) shall be submitted by the manufacturer, provided the approved target chemical composition range remains unchanged.

3.19.2.3.3 Base metal test.

3.19.2.3.3.1 Charpy V-notch impact tests (KV).

3.19.2.3.3.1.1 Generally Charpy V-notch impact testing shall be carried out in compliance with **2.2.3**. Test samples shall be taken from the plate corresponding to the top of the ingot, unless otherwise specified.

Table 3.19.2.2.1-1. **Conditions of supply, grade and mechanical properties for YP47 steel plates**

Supply condition	**Grade**	**Mechanical properties**			**Impact test**			
		Yield strength, MPa, min	Tensile strength, MPa	Elongation, %, min	Test temperature, °C	Average impact energy, J, min		
						$50< t \le 70$	$70< t \le 85$	$85< t \le 100$
TMCP[1]	EH47	460	570/720	17	-40	53	64	75

[1] If specified in the documentation approved by the Register.
Note. t - thickness, in mm.

Table 3.19.2.2.1-2. **Chemical compositions for YP47 steel plates**

Chemical composition	C_{eq} [1]	P_{CM} [2]
Minimum value	≤ 0,49	≤ 0,22

[1] 1 The carbon equivalent C_{eq} value shall be calculated from the ladle analysis using the formula C_{eq} = C + Mп/6 + (Cr + Mo + V)/5 + (Ni + Cu)/15, %.
[2] Cold cracking susceptibility shall be calculated using the formula:
P_{CM} = C + Si/30 + Mп/20 + Cи/20 + Ni/60 + Cг/20 + Mo/15 + V/10 + 5B, %.

In the case of continuous castings, test samples shall be taken from a randomly selected plate. The location of the test sample shall be at the square cut end of the plate, approximately one quarter width from an edge, as shown in Fig. 3.19.2.3.3.1.

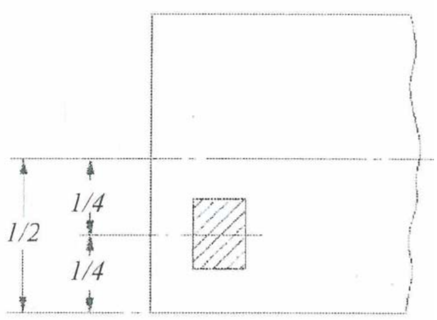


Fig. 3.19.2.3.3.1 Plates and flats

Samples shall be taken with respect to the principal rolling direction of the plate at locations representing the top and bottom of the plate as follows:

longitudinal Charpy V-notch impact tests (*KVL*) – top and bottom;

transverse Charpy V-notch impact tests (*KVT*) – top only;

aged longitudinal Charpy V-notch impact tests – top only.

Charpy V-notch impact tests (*KV*) are required from both the quarter and mid thickness locations of the test samples.

One set of 3 Charpy V-notch impact specimens (*KV*) is required for each impact test. The pact test temperature shall be – 40°C .

In addition to the determination of the energy value, during impact tests the percentage crystallinity shall be also determined.

The aged samples shall be strained to 5 % followed by heating to 250°C for 1 h prior to testing.

Additionally at each location, Charpy V-notch impact tests shall be carried out with appropriate temperature intervals to properly define the full transition range (-20°C, -40°C, -60°C, -80°C) on *KV* type of samples from 1/4 strip thickness.

3.19.2.3.3.2 Test for resistance to brittle fracture.

3.19.2.3.3.2.1 CTOD test shall be carried out and the result shall be reported. Test methods shall be in compliance with **2.2**, Part XII "Materials" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms.

3.19.2.3.3.3 Drop weight testing for determining nil-ductility temperature (NDT).

3.19.2.3.3.3.1 Test methods shall be in compliance withASTM E208.

Nil-ductility temperature (NDT) shall be reported for reference.

3.19.2.3.3.4 Brittle crack stopping test.

3.19.2.3.3.4.1 ESSO test described in **3.20.6** or other alternative test (double tension test) shall be carried out in order to obtain the brittle crack stopping toughness.

3.19.2.3.4 Weldability test.

3.19.2.3.4.1 Charpy V-notch impact test (KV).

3.19.2.3.4.1.1 Charpy V-notch impact tests shall be taken at a position of 1/4 thickness from the plate surface on the face side of the weld with the notch perpendicular to the plate surface.

One set of the specimens transverse to the weld shall be taken with the notch located at the fusion line and at a distance 2,5 and minimum 20 mm from the fusion line. The fusion boundary shall be identified by etching the specimens with a suitable reagent. One additional set of the specimens shall be taken from the root side of the weld with the notch located at the same position and at the same depth as for the face side.

The impact test temperature shall be-40°C.

Additionally at each location, impact tests shall be carried out with appropriate temperature intervals to properly define the full transition range.

3.19.2.3.4.2 Y-shape weld hydrogen crack resistance test.

3.19.2.3.4.2.1 The test methods shall be in compliance with recognized national or international standards such as, ISO 17642-2 , KS B 0870, JIS Z 3158, GB 4675.1.

Acceptance criteria shall be in accordance with the Register practice. 3.19.2.3.4.3 Test for resistance to brittle fracture.

3.19.2.3.4.3.1 CTOD test shall be carried out. Test method and results shall be considered appropriate by the Register-approved documentation.

3.19.2.4 Welding.

3.19.2.4.1 Welders.

3.19.2.4.1.1 Welders engaged in YP47 steel welding shall possess welder's qualifications specified in accordance with Section **5** Part XIV «Welding».

3.19.2.4.2 Short beads.

3.19.2.4.2.1 Short bead length for tack and repairs of welds by welding shall not be less than 50 mm.

In the case where $P_{CM} \leq 0{,}19$, 25 mm of short bead length may be adopted.

3.19.2.4.3 Preheating.

3.19.2.4.3.1 Preheating shall be50°C or over when air temperature is 5°C or below .

3.19.2.4.3.1 In the case where $P_{CM} \leq 0{,}19$, air temperature of 0°C or below may be adopted.

3.19.2.4.4 Welding consumables.

3.19.2.4.4.1 Specifications of welding consumables for YP47 steel plates are given in Table 3.19.2.4.4-1.

Table 3.19.2.4.4-1. **Mechanical properties for deposited metal tests for welding consumables**

Механічні властивості			**Випробування на ударний вигин (*KV*)**	
Yield strength, MPa, min	Tensile strength, MPa	Elongation, %, min	Test temperature, °C	Average impact energy, J, mi
460	570/720	19	-20	53

Mechanical properties of butt weld assemblies for acceptance of consumables shall be in accordance with Table 3.19.2.4.4-2.

Таблиця 3.19.2.4.4-2. **Mechanical properties for butt weld tests for welding consumables**

Tensile strength, MPa	**Bend test ratio: *D/t***	**Випробування на ударний вигин (*KV*)**		
		Test temperature, °C	Average impact energy, J, min	
			Welding position	
			Downhand, horizontal-vertical, overhead	Vertical (upward and downward)
570/720	4	- 20	53	53

3.19.2.4.5 Others.

3.19.2.4.5.1 Special care shall be paid to the final welding so that harmful defects do not remain. Jigs shall be completely removed with no defects, otherwise the treatment of the jigs shall be agreed with the Register.

3.19.2.5 Welding procedure qualification test.

3.19.2.5.1 General.

3.19.2.5.1.1 Unless otherwise specified in this Chapter, qualification test items, test methods and acceptance criteria shall be in compliance with Section 6, Part XIV «Welding».

3.19.2.5.2 Range of approval.

3.19.2.5.2.1 The requirements of Section 6, Part XIV «Welding».

3.19.2.5.3 Charpy V-notch impact test (KV).

3.19.2.5.3.1 The requirements of Section **4**, Part XIV «Welding». Average impact energy 64 J at – 20°C shall be satisfied for impact test.

3.19.2.5.4 Hardness.

3.19.2.5.4.1 Vickers hardness HV10, as defined in Section 4, Part XIV «Welding», shall be not more than 380. Measurement points shall include mid-thickness position.

3.19.2.5.5 Tensile test.

3.19.2.5.5.1 Tensile strength in transverse tensile test shall be not less than 570 MPa.

3.19.2.5.6 Test for resistance to brittle fracture.

3.19.2.5.6.1 CTOD test may be required. Test methods and acceptance criteria shall be in compliance with **2.2**, Part XII "Materials", Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms.

3.20 REQUIREMENTS FOR USE OF EXTREMELY THICK STEEL PLATES IN CONTAINER SHIPS

3.20.1 Scope of application.

3.20.1.1 General.

3.20.1.1.1 These requirements apply to the container carriers incorporating extremely thick steel plates in accordance with **3.20.1.2** and **3.20.1.3**.

3.20.1.1.2 The Section gives measures for identification and prevention of brittle fractures of container carriers to which extremely thick steel plates are applied for longitudinal structural members, as well as basic variants for application of extremely thick steel plate in the hull longitudinal members of the upper deck, such as: upper deck plating, hatch side coaming, hatch coaming top, etc.

3.20.1.1.3 The application of the measures specified in 3.20.2 to 3.20.4 shall comply with 3.20.5.

3.20.1.1.4 The properties of welded joints shall comply with 4, 6, Part XIV "Welding" and requirements of this Chapter.

3.20.1.2 Steel grade.

3.20.1.2.1 These requirements apply to the container carriers, to which any of YP36, YP40 and YP47 steel plates are used for the longitudinal structure members, having the thickness specified in **3.20.1.3**.

3.20.1.2.2 Steel designations used herein: YP36, YP40 and YP47 mean the steel plates having the minimum specified yield points of 355, 390 and 460 MPa, respectively.

3.20.1.3 Thickness.

3.20.1.3.1 These requirements apply to the steel plates with thickness from 50 to 100 mm inclusive.

3.20.1.3.2 For container ships' hull structures made of steel plates with thickness exceeding 100 mm appropriate measures for prevention of brittle crack initiation and propagation shall be agreed with the Register.

3.20.2 Non-destructive testing (NDT) during construction (measure 1, Table 30.2.5.)

Where NDT during construction is required in **3.20.5**, the NDT shall be in accordance with **3.20.2.1** and **3.20.2.2**.

Enhanced NDT as specified in **3.20.4.3.1.2.4** shall be carried out in compliance with the documents approved by the Register and recognized standards.

3.20.2.1.1 General.

3.20.2.1.1.1 Ultrasonic testing in compliance with Section 3, Part XIV "Welding" shall be carried out on all block-to-block butt joints of all upper flange longitudinal structural members in the cargo hold region, including include the topmost strakes of the inner hull/bulkhead, the sheer strake, main deck, coaming plate, coaming top plate, and all attached longitudinal stiffeners (refer to Fig. 3.20.2.1).

3.20.2.2 Acceptance criteria of ultrasonic testing.

3.20.2.2.1 Acceptance criteria of ultrasonic testing shall be in compliance with Section 3, Part XIV "Welding" documentation approved by the Register and/or recognized standards.

3.20.2.2.2 The acceptance criteria may be adjusted under consideration of the appertaining brittle crack initiation prevention procedure, and where this is more severe than that found in the Rules and standards to be amended accordingly to a more severe sensitivity.

3.20.3 Periodic NDT after delivery (measure 2, Table 30.2.5.)

Where periodic NDT after delivery is required, the NDT shall be in accordance with **3.20.3.1 - 3.20.3.3**.

3.20.3.1.1 General.

3.20.3.1.1.1 The procedure of the NDT shall be in accordance with 3.2 and the documentation approved with the Register for the steel supply.

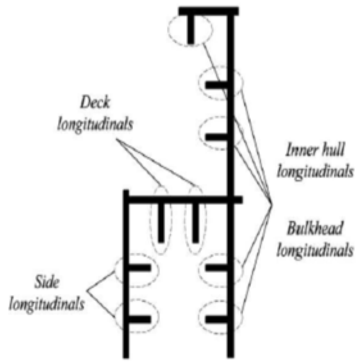


Fig. 3.20.2.1 Upper flange longitudinal structural members

3.20.3.2 Timing of ultrasonic testing.

3.20.3.2.1 Where ultrasonic testing is carried out, the frequency of survey shall be in compliance with the Register requirements.

3.20.4 Brittle crack stopping design (measures 3, 4 and 5, Table 30.2.5.)

3.20.4.1 General.

3.20.4.1.1 Measures for prevention of brittle crack propagation in the cargo hold region.

3.20.4.1.2 It shall be noted that cracks can initiate and propagate away from such joints, therefore, appropriate measures shall be considered in accordance with **3.20.4.2.1.2.2**.

3.20.4.1.3 The requirements to crack resistance specified in the Section cover the YP36, YP40 and YP47 steels equally.

Crack resistance shall be determined according to this para at the stage of manufacturer recognition. Brittle crack stopping steel is defined as steel plate with measured crack stopping properties $K_{ca} > 6000$ N/mm $^{3/2}$.

Where the thickness of the steel exceeds 80 mm, the required K_{ca} value shall be approved by the Register as part of the submitted documentation.

Brittle crack stopping steel parameters, as well as the appropriate methods to determine shall be agreed with the Register (e.g. T_{kb} not exceeding – 10°C).

3.20.4.2 Functional requirements of brittle crack stopping design.

3.20.4.2.1 The purpose of the brittle crack stopping design is aimed at stopping propagation of a crack at a proper position and to prevent large scale fracture of the hull girder:

.1 the point of a brittle crack initiation shall be considered in the block-to-block butt joints both of hatch side coamings and upper deck;

.2 the following cases shall be considered:

.2.1 where the brittle crack runs straight along the butt joint;

.2.2 where the brittle crack starts in the butt joint but deviates away from the weld and runs into the plate or starts in a secondary weld and runs into the plate (refer to Fig. 3.20.4.2.1.2.2).

3.20.4.3 Concept examples of brittle crack stopping design.

3.20.4.3.1 The following are considered to be acceptable examples of brittle crack stopping design.

3.20.4.3.1.1 Brittle crack stopping design for **3.20.4.2.12.2**:

.1 brittle crack stopping steel shall be used for the upper deck along the cargo hold region in a way suitable to stop a brittle crack initiating from the coaming and propagating into the structure below.

3.20.4.3.1.2 Brittle crack stopping design for **3.20.4.2.1.2.1**:

.1 where the block-to-block butt welds of the hatch side coaming and those of the upper deck plating are shifted, this shift shall be greater than or equal to 300 mm. Brittle crack stopping steel shall be provided for the hatch side coaming;

.2 where crack stopping holes are provided in way of the block-to-block butt welds at the region where hatch side coaming weld meets the deck weld, the fatigue strength of the lower end of the butt weld shall be assessed.

Additional countermeasures shall be taken for the possibility that a running brittle crack may deviate from the weld line into upper deck or hatch side coaming.

These countermeasures shall include the application of brittle crack stopping steel in hatch side coaming;

.3 where stopping insert plates of brittle crack stopping steel or weld metal inserts with high crack stopping toughness properties are provided in way of the block-to-block butt welds at the region where hatch side coaming weld meets the deck weld, additional countermeasures shall be taken for the possibility that a running brittle crack may deviate from the weld line into upper deck or hatch side coaming.

These countermeasures shall include the application of brittle crack stopping steel in hatch side coaming;

.4 the application of enhanced NDT particularly time of flight diffraction (TOFD) technique using stricter defect acceptance in lieu of standard ultrasonic testing technique specified in **3.20.2** can be an alternative to **3.20.4.3.1.2.1 ÷ 3.20.4.3.1.2.3.**

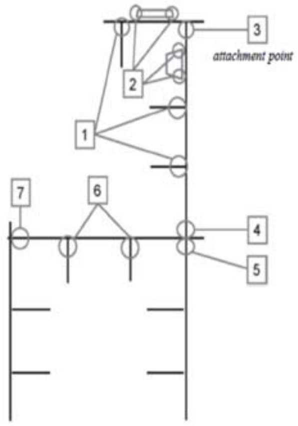


Fig. 3.20.4.2.1.2.2 Zones of the secondary welds through the example of the support securing

Where: **1 -** fillet welds in the place of the hatch side coaming (including the coaming top) contact with longitudinal members;

2 -fillet welds in the place of the hatch side coaming (including the coaming top and longitudinal member) contact with attachment joints. For example, fillet welds in the place of the hatch cover contact with the support;

3 -fillet welds in the place of the hatch coaming top contact with the hatch side coaming;

4 -fillet welds in the place of the hatch side coaming contact with the upper deck plating;

5 -fillet welds in the place of the upper deck plating contact with the bulkheads;

6 -fillet welds in the place of the upper deck plating contact with the longitudinal beams;

7 -fillet welds in the place of the sheerstrake contact with the upper deck plating.

3.20.5 Measures for detecting and prevention of brittle fracture of hull structures of container carrier ships made of extremely thick steel plates.

The thickness and the yield strength shown in Table 3.20.5. apply to the hatch coaming top structure and hatch side coaming steel, and are the controlling parameters for the application of countermeasures.

If the as-built thickness of the hatch top coaming and hatch side coaming structure is below the values given in Table 3.20.5, countermeasures are not necessary regardless of the thickness and yield strength of the upper deck steel.

3.20.6 Standard ESSO test.

3.20.6.1 Scope of application.

3.20.6.1.1 The ESSO test method is used to estimate the brittle crack stopping toughness value K_{ca} of rolled steel plates for hull of thickness 100 mm or less.

3.20.6.2 The symbols and arrangement of test specimen, holder and fixtures are given in Table 3.20.6.2 and in Fig. 3.20.6.2, respectively.

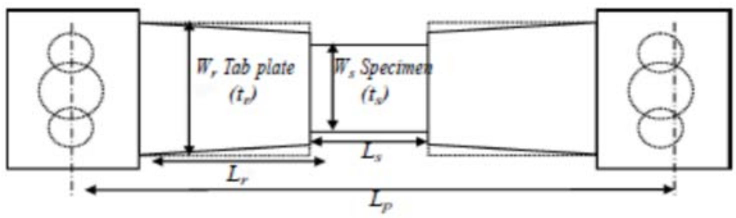


Fig. 3.20.6.2 Conceptual view of test specimen, tab and load jig

3.20.6.3 Purpose.

3.20.6.3.1 The purpose of this test shall encourage the performance of a standard test for assessment of brittle crack stopping toughness with temperature gradient and to obtain the corresponding brittle crack stopping toughness value K_{cu}.

3.20.6.4 Standard test specimen.

3.20.6.4.1 Fig. 3.20.6.4.1 shows the shape and size of the standard test specimen.

***Table 3.20.5.* Symbols used and their meanings**

Tensile strength, MPa	Thickness, mm	Option[1]	Measures			
			1	2	3 ÷ 4	5
1	**2**	**3**	**4**	**5**	**6**	**7**
36	$50 < t \leq 85$	–	N/A	N/A	N/A	N/A
	$85 < t < 100$	–	X	N/A	N/A	N/A
40	$50 < t \leq 85$	–	X	N/A	N/A	N/A
	$85 < t \leq 100$	A	X	N/A		X
		B	X[2]	N/A[3]	N/A	X
47 FCAW (arc weldin g with powde r wire))	$50 < t \leq 100$	A	X	N/A		X
		B	X[2]	N/A[3]	N/A	X
47EGW (gaselectri c weldin g)	$50 < t \leq 100$	–	X	N/A		X

[1] Selectable from option A or B.
[2] Refer to **3.20.4.3.4**.
[3] Refer to **3.20.4.3**
Symbol: X –to be applied
Measures (to Table 3.20.5.):
1. Non-destructive testing of all welded joints according to **3.20.2** (during construction).
2. Periodic non-destructive testing after delivery of steel (during construction).
3. Brittle crack stopping design against straight propagation of brittle crack along weldline (during construction). Refer to **3.20.4.3.1.2.1**, **3.20.4.3.1.2.2**.
4. Brittle crack stopping design against deviation of brittle crack from weldline (during construction). Refer to **3.20.4.3.1.1.1**.
5. Brittle crack stopping design against propagation of cracks from secondary weld areas (refer to Fig. 3.20.4.2.1.2.2) such as fillets and attachment welds (during construction). Refer to **3.20.4.3.1.1.1**.

***Table 3.20.6.2.* Symbols used and their meanings**

Symbol	Unit	Meaning
t_s	mm	Thickness of test specimen
W_s	mm	Width of test specimen
L_s	mm	Length of test specimen
t_r	mm	Thickness of tab plate
W_r	mm	Width of tab plate
L_r	mm	Length of tab plate
L_p	mm	Distance between pins
a	mm	Length of crack projected on surface normal to the line of load
a_a	mm	Maximum crack length at brittle crack stopping position
T	°C	Temperature of test specimen
dT/da	°C/ mm	Temperature gradient of test specimen
σ	H/ mm^2	Gross stress in tested part (load / WS.tS)
K_{ca}	H/ mm$^{3/2}$	Brittle crack stopping toughness value

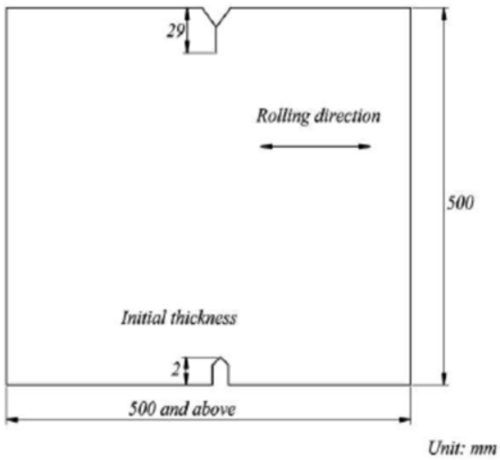


Fig. 3.20.6.4.1 Shape and size of test specimen

3.20.6.4.2 The thickness and width of the test specimen shall be in accordance with Table 3.20.6.4.2.

Table 3.20.6.4.2. **Thickness and width of test specimen**

Thickness t_s	100 mm and below
Width of test specimen W_s	500 mm
Note. If the width of the test specimen cannot be made at 500 mm, it may be taken as 600 mm.	

3.20.6.4.3 The test specimens shall be taken from the same steel plate.

3.20.6.4.4 Test specimens shall be taken in such a way that the axial direction of the load is parallel to the rolling direction of the steel plate.

3.20.6.4.5 The thickness of the test specimen shall be the same as the thickness of the steel plate to be used in the ship's hull structures.

3.20.6.5 Test equipment.

3.20.6.5.1 The test equipment to be used shall consist of pin load type hydraulic test equipment capable of tensile tests.

3.20.6.5.2 The distance between the pins shall be not less than 2000 mm.

3.20.6.5.3 Drop weight type or air gun type impact equipment may be used for the impact energy required for generating brittle cracks.

3.20.6.5.4 The wedge shall have an angle greater than the upper notch of the test specimen, and an opening force shall be applied on the notch.

3.20.6.5.5 An opening force shall be applied to the notch.

3.20.6.6 Test preparation.

3.20.6.6.1 The test piece shall be fixed directly to the pin load jig or by means of weld joint through the tab plate.

The overall length of the test specimen and tab plate shall be not less than $3W_s$.

The thickness and width of the tab plate shall be in accordance with Table 3.20.6.6.1.

Table 3.20.6.6.1. **Allowable dimensions of tab plate**

	Thickness t_r	**Width W_r**
Dimensions of tab plate	$0{,}8\ t_s \leq t_r \leq 1{,}5\ t_s$	$W_s \leq W_r \leq 2W_s$
Notes: 1. t_s - thickness of test specimen. 2. If the tab plate has a thickness smaller than the test specimen, the reflection of stress wave will be on the safer side for the assessment; therefore, the minimum value of thickness is taken as 0,8 t_s.		

3.20.6.6.2 Thermocouples shall be fitted at 50 mm pitch on the notch extension line of the test specimen.

3.20.6.6.3 If the brittle crack is estimated to deviate from its presumed course, thermocouples shall be fitted at two points separated by 100 mm on the line of load from the notch extension line at the centre of width of the test specimen.

3.20.6.6.4 If dynamic measurements are necessary, strain gauges shall be fitted at specific locations.

3.20.6.6.5 The test specimen shall be fixed to the testing machine together with the tab plate after welding and the pin load jig.

3.20.6.6.6 The impact equipment shall be mounted. The construction of the impact equipment shall be such that the impact energy is correctly transmitted. An appropriate jig shall be arranged to minimize the effect of bending load due to the impact equipment.

3.20.6.7 Test method.

3.20.6.7.1 To eliminate the effect of residual stress or correct the angular deformation of tab welding, a preload less than the test load may be applied before cooling.

3.20.6.7.2 Cooling and heating may be implemented from one side on the side opposite the side on which the thermocouple is fitted, or from both sides.

3.20.6.7.3 The temperature gradient shall be controlled in the range of 0,25 ÷ 0,35°C/mm in the range of width from $0{,}3W_s \div 0{,}7W_s$ at the central part of the test specimen.

3.20.7.4 When the specific temperature gradient is reached, the temperature shall be maintained for more than 10 min, after which the specified test load shall then be applied.

3.20.6.7.5 After maintaining the test load for at least 30 s, a brittle crack shall be generated by impact. The standard impact energy is taken as 20 to 60 J per 1 mm plate thickness.

If the brittle crack initiation characteristics of the base metal are high, and it is difficult to generate a brittle crack, the impact energy may be increased to the upper limit of 120 J per 1 mm plate thickness.

3.20.6.7.6 Loading is stopped when the initiation, propagation, and stopping of brittle crack have been confirmed. Normal temperature is restored, and if necessary, the ligament is broken by gas cutting and forcibly the specimen is broken by using the testing machine. Or, after the ductile crack has been propagated to an adequate length with the testing machine, the ligament is broken by gas cutting.

3.20.6.7.7 After forcing the fracture, photos of the fractured surface and the propagation route shall be taken, and the crack length shall be measured.

3.20.6.8 Test results.

3.20.6.8.1 The distance from the top of the test specimen, including the notch to the maximum length in the plate thickness direction of the arrested crack tip, shall be measured.

If the crack surface deviates from the surface normal to the line of load of the test specimen, the projected length on the surface normal to the line of load shall be measured. In this case, if the trace of brittle crack stopping is clearly visible on the fractured surface, the first crack stopping position is taken as the stopping crack position.

3.20.6.8.2 From the results of thermocouple measurement, the temperature distribution curve shall be plotted, and the stopping crack temperature shall be measured corresponding to the stopping crack length.

3.20.6.8.3 The brittle crack stopping toughness value K_{ca} of each test shall be determined by using the following formula:

$$K_{ca} = \sigma \cdot \sqrt{(\pi \cdot \alpha)} \cdot \sqrt{\{2 \cdot W_s \cdot \tan[\pi \cdot \alpha/(2 \cdot W_s)]\}} \qquad (3.20.6.8.3)$$

3.20.9 Report.

3.20.6.9.1 The following items shall be reported:

.1 testing machine specifications; testing machine capacity, distance between pins L_p;

.2 load jig dimensions; tab plate thickness t_r, tab plate width W_r, test specimen length including tab plate $L_s + 2\,L_r$;

.3 test specimen dimensions; plate thickness t_x; test specimen width W_s and length L_s;

.4 test conditions; preload stress, test stress, temperature distribution (figure or table); impact energy;

.5 test results; crack arrest length a_a; temperature gradient at stopping position, brittle crack stopping toughness K_{ca};

.6 dynamic measurement results (if measurement is carried out); crack growth rate, strain change;

.7 test specimen photos; fracture route, fractured surface.

3.20.6.9.2 If the conditions below are not satisfied, the test results shall be treated as reference values.

.1 the brittle crack stopping position shall be in the range of the hatched part shown in Fig. 3.20.6.9.2.1. In this case, if the brittle crack stopping position is more than 50 mm away from the centre of the test specimen in the longitudinal direction of the test specimen, the temperature of the thermocouple at the ±100 mm position shall be within ±3°C of the thermocouple at the centre;

.2 the brittle crack shall not have a distinct crack bifurcation while it propagates.

3.20.6.9.3 From effective test results measured at more than 3 points, the linear approximation equation shall be determined on the Arrhenius plot, and K_{ca} at the desired temperature shall be calculated.

In this case, data shall exist on both sides, that is, the high temperature and low temperature sides around the assessed temperature.

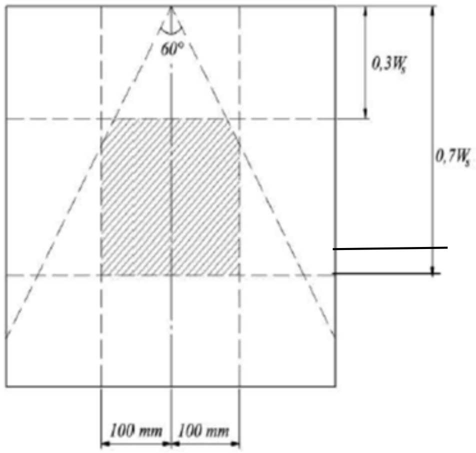


Fig. 3.20.6.9.2.1. Necessary conditions of stopping crack position

4. COPPER AND COPPER-BASE ALLOYS

4.1 SEMI-FINISHED PRODUCTS OF COPPER AND COPPER-BASE ALLOYS

4.1.1 General.

These requirements apply to semi-finished products of copper and copper-base alloys (rolled, forged, drawn, press-formed, etc.) and castings, which are used in shipbuilding and marine engineering, and the manufacture of which is subject to the Register survey.

Semi-finished products of copper and copper-base alloys shall be manufactured at works recognized according to **1.3.1.4**.

4.1.2 Chemical composition and mechanical properties.

The chemical composition and mechanical properties of copper and copper-base alloys products such as pipes, plates, bars, rolled sections, forgings and castings shall meet the requirements of appropriate standards or specifications approved by the Register.

When selecting copper-base alloys, one shall consider the required level of mechanical properties at indoor or higher temperatures, corrosion resistance, and other properties determined by their application.

4.1.3 Condition of supply.

If, in the process of manufacture, parts made of copper and copper-base alloys are subjected to heat treatment, the type of heat treatment shall be reported to the Register and stated in the Manufacturer's Certificate for material.

Rolled products made of CuZn alloys (brasses) shall be annealed for stress relieving.

Products in solid and semi-solid condition may be used only upon agreement with the Register.

4.1.4 Sampling.

Tensile test samples shall be cut from plate material transversely to the direction of rolling (forging), and from tubes, rods, sections and forgings - longitudinally to the direction of rolling.

Tubes, rods and sections with a diameter (or thickness) of 40 mm and less may be subjected to tensile tests in the rough condition.

Forging samples may be forged separately or forged on the forgings.

The samples shall have the same degree of upsetting as the forging in its highest loaded cross-section.

Casting samples may be separately cast, cast-on or cut out from the casting.

In any case, the samples shall be cut after the final heat treatment (in the supply condition).

4.1.5 Scope of testing.

If not otherwise specified, the following samples shall be taken from each batch:

for determination of chemical composition (heat analysis);

for determination of mechanical properties (R_m, R_{eH}, A_5),

for fabrication testing.

The scope of testing for semi-finished products (rolled products, forgings, castings) shall be determined according to standards recognized by the Register.

CuZn alloy tubes for heat exchangers shall be subjected to the following tests:

mercuric nitrate or ammonia treatment according to the requirements of appropriate standards (one specimen per lot);

flattening (two specimens cut from two tubes, H=3t);

expanding (two specimens from two tubes, with the angle of mandrel paper $\alpha = 45°$, and the expansion degree of 30 %);

microstructure check (one specimen per lot).

Average grain diameter shall be 0,01 to 0,05 mm.

Tubes shall be subjected to hydraulic testing; the test pressure shall be determined by standards or specifications.

In justified cases substitution of non-destructive testing for hydraulic testing is permitted.

4.1.6 Inspection.

Products submitted for the Register inspection shall comply with the requirements of corresponding standards or specifications, on the basis of which they are accepted.

The products shall not have defects, which are detrimental for their intended use.

4.1.7 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of **1.4**.

4.2 PROPELLER CASTINGS

4.2.1 General.

4.2.1.1 These requirements apply to castings intended for cast propellers, blades and bosses of propellers with detachable blades.

The requirements are applicable to moulding, casting, inspection of new propellers, blades and bosses as well as repair of new propellers in the course of their manufacture.

Upon special consideration these requirements may also be applied for the repair and inspection of propellers becoming damaged during service.

4.2.1.2 All propellers and their components shall be cast by foundries approved by the Register in compliance with **1.3.1.4**.

The application for approval shall be accompanied by specifications of the propeller materials, manufacturing procedures, repair, non-destructive testing and a description of the foundry facilities, including the maximum capacity of the ladles.

4.2.1.3 The approval tests shall be carried out in compliance with **1.3.5** under the programme approved by the Register.

The purpose of the tests shall verify that the castings and their quality, including chemical composition and mechanical properties, comply with these requirements.

4.2.1.4 The foundry shall have an adequately equipped laboratory, manned by experienced personnel, for the testing of moulding materials, chemical analyses, mechanical testing and microstructural testing of metallic materials.

Provision shall be made for non-destructive testing. If these test facilities are not available, details shall be provided of an approved local laboratory which will provide such services. The laboratory, shall be recognized by an authorized national body and/or Register.

4.2.1.5 The pouring shall be carried out into dried moulds using degassed liquid metal. The pouring shall be controlled as to avoid turbulences of flow. Special devices and/or procedures shall prevent slag flowing into the mould.

4.2.1.6 Subsequent stress relieving heat treatment may be performed to reduce the residual stresses. For this purpose, the manufacturer shall submit a specification containing the details of the heat treatment to the Register for approval (refer to Tables 4.2.8.5-1 and 4.2.8.5-2).

4.2.2 Chemical composition and structure characteristics.

4.2.2.1 The chemical composition of typical copper-base alloys for propellers shall comply with the requirements of Table 4.2.2.1.

Note: The main constituents of the microstructure in the copper-base alloys categories CU1 and CU2 are alpha and beta phase. Important properties such as ductility and resistance to corrosion fatigue are strongly influenced by the relative proportion of beta phase (too high percentage of beta phase having a negative effect on these properties). To ensure adequate cold ductility and corrosion fatigue resistance, the proportion of beta phase shall be kept low. The concept of the zinc equivalent shall be used as control since it summarizes the effect of the tendency of various chemical elements to produce beta phase in the structure.

The structure CU1 and CU2 type alloys shall con-tain an alpha phase component of at least 25 %. The content of alpha phase shall be measured by the manufacturer. The zinc equivalent defined by the following formula shall not exceed a value of 45 %.

$$\text{Zinc equivalent (\%)} = 100 - \frac{100\ \%\ \text{Cu}}{100 + A}, \quad \%,$$

where A – is the algebraic sum of the following values:

1×% Sn; 5×% Al; –0,5×% Mn; –0,1×% Fe; –2,3×% Ni.

The negative sign in front of the elements Mn, Fe and Ni signifies that these elements tend to reduce the proportion of beta phase.

Copper-base alloys of chemical composition different from those given in Table 4.2.2 may be all allowed in accordance with national or international standards recognized by the Register.

Table 4.2.2.1

Alloy type	Chemical composition of copper-base alloys for propellers, %							
	Cu	Al	Mn	Zn	Fe	Ni	Sn	Pb
CU1	52–62	0,5–3,0	0,5–4,0	35–40	0,5–2,5	max 1.0	0,1–1,5	max 0,5
CU2	50–57	0,5–2,0	1,0–4,0	33–38	0,5–2,5	3,0–8,0	max 0,15	max 0,05
CU3	77–82	7,0–11,0	0,5–4,0	max 1,0	2,0–6,0	3,0–6,0	max 0,1	max 0,03
CU4	70–80	6,5–9,0	8,0–20,0	max 6,0	2,0–5,0	1,5–3,0	max 1,0	max 0,05

Note: Chemical composition shall be determined for the metal of each ladle.

4.2.3 Mechanical properties.

Mechanical properties of standardized alloys as applied to test specimens taken from separately cast samples shall comply with Table 4.2.3.

These properties are a measure of the mechanical quality of each heat; and they are generally not representative of the mechanical properties of the propeller casting itself, which may be up to 30 % lower than that of a separately cast samples. The requirements for mechanical properties of cast-on specimens or those cut out from the casting are specified in accordance with the approved documentation.

Copper alloys with mechanical characteristics different from those given in Table 4.2.3 may be allowed only after their approval by the Register in compliance with **1.3.1.4**.

Table 4.2.3. **Mechanical properties of copper-base alloys for propellers (separately cast samples)**

Alloy type	Yield stress, $R_{p0,2}$, MPa, min	Tensile strength, R_m, MPa, min	Elongation, A_5, %, min
CU1	175	440	20
CU2	175	440	20
CU3	245	590	16
CU4	275	630	18

4.2.4 Sampling.

Separately cast samples for determining the mechanical properties of propeller alloys shall be taken from each ladle and shall have the dimensions as shown in Fig. 4.2.4.

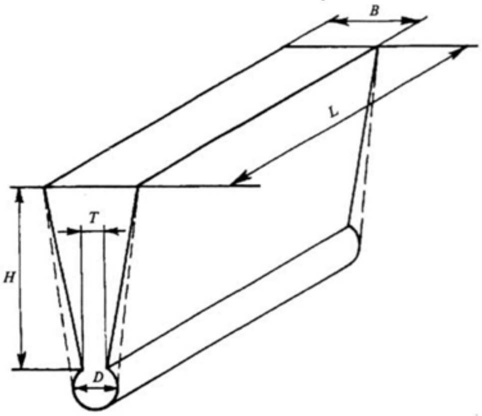


Fig.4.2.4 Separately cast sample with dimensions in mm: H=100,B=50,L>150,T=15,D=25

Samples may be prepared in accordance with the standards approved by the Register.

For the purpose of approval of a foundry the tests indicated in Table 4.2.1.3 may be carried out on separately cast samples and specimens of cast-on metal or casting metal.

4.2.5 Scope of tests.

Out of each sample at least one cylindrical specimen is machined to undergo the tensile test (refer to Table 2.2.2.3). The tensile strength, proof stress and elongation shall be determined by tensile test.

Generally, the specimens shall be taken from separately cast samples (refer **to 4.2.4**).

The samples shall be cast in moulds made of the same material as the mould for propeller. They shall be cooled down under the same conditions as the propeller. If propellers are subjected to a heat treatment the samples shall be heat treated together with them.

Where use of cast-on samples specimens is approved by the Register, they shall, wherever possible, be located on the blades in an area lying between 0,5R to 0,6R, where R is the radius of the propeller. The sample material shall be removed from the casting by non-thermal procedures.

For CU1 and CU2 alloy types the proportion of alpha phase is determined. For this purpose, at least one specimen shall be taken from each cast.

The proportion of alpha phase shall be determined as the average value of 5 counts. The requirements of **4.2.2.1** shall be fulfilled.

4.2.6 Severity zones (repair zones).

4.2.6.1 In order to relate the degree of inspection to the criticality of defects in propeller blades and to help reduce the risk of failure by fatigue cracking after repair, propeller blades are divided into the three zones designated A, B and C (refer to Figs. 4.2.6.2-1 and 4.2.6.3).

Note: Propellers are divided into high skew propellers, i.e. propellers with a skew angle greater than 25°, and low skew propellers with a skew angle of up to 25°.

The skew of the propeller is defined as the angle, in projected view of the blade, between a line drawn through the blade tip and the shaft centreline and a second line through the shaft centreline, which acts as a tangent to the locus of the mid-points of the helical blade section (refer to Fig. 4.2.6.1).

4.2.6.2 Severity zones for low-skew propeller blades.

Zone A is in the area on the pressure side of the blade, from and including the fillet to 0,4*R*, and bounded on either side by lines at a distance 0,15 times the chord length C_r from the leading edge and 0,2 times C_r from the trailing edge, respectively, as shown in Fig. 4.2.6.2-1 (C_r is the chord width of the blade on radius 0,4R.

Where the hub radius (R_b) exceeds 0,27R, the other boundary of zone *A* shall be increased to 1,5 R_b.

Zone A also includes the parts of the separate cast propeller hub, which lie in the area of the windows as described in Fig. 4.2.6.2-2, and the flange and fillet area of controllable pitch and built-up propeller blades as described in Fig. 4.2.6.2-3.

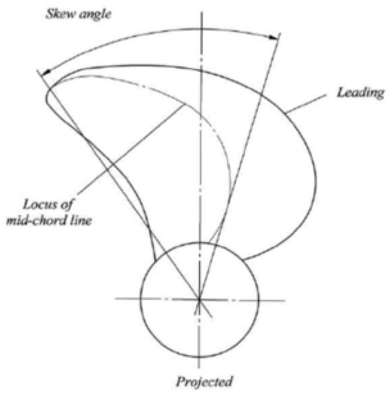


Fig. 4.2.6.1. Definition of skew angle

Zone B is the area on the pressure and suction sides of the blade. On the pressure side zone *B* is the remaining area up to 0,7*R* (the area within the boundaries of 0,4*R* and 0,7*R* plus areas on the leading and trailing edges bounded by lines 0,15 C_r and 0,2 C_r, respectively, and the line over the blade length with a radius of 0,4*R*) as described in Fig. 4.2.6.2-1.

On the suction side zone B is the area from the fillet to 0,7*R*.

Zone C is the area outside 0,7*R* on both pressure and suction sides of the blade (between 0,7R and R) as described in Fig. 4.2.6.2-1. It also includes all the surfaces of the hub other than those designated zone *A* above.

4.2.6.3 Severity zones for high-skew propellers.

Zone A is the area on pressure and suction sides of the blade as described in Fig. 4.2.6.3.

On the pressure face zone *A* is contained within the blade root-fillet and a line running from the junction of the leading edge with the root fillet to the trailing at 0,9*R* and at passing through the mid-point of the blade chord at 0,7*R* and a point situated at 0,3 of the chord length from the leading edge at 0,4*R*. Zone *A* also includes an area between the above line and the edge from the root to the chord at 0,4*R*.

Zone A includes an area along the trailing edge on the suction side of the blade from the root to 0,9*R* and with its inner boundary at 0,15 of the chord lengths from the trailing edge.

Zone B is the area of the pressure and suction sides of the blade as described in Fig. 4.2.6.3.

Zone B includes the blade surfaces not included in zone *A*.

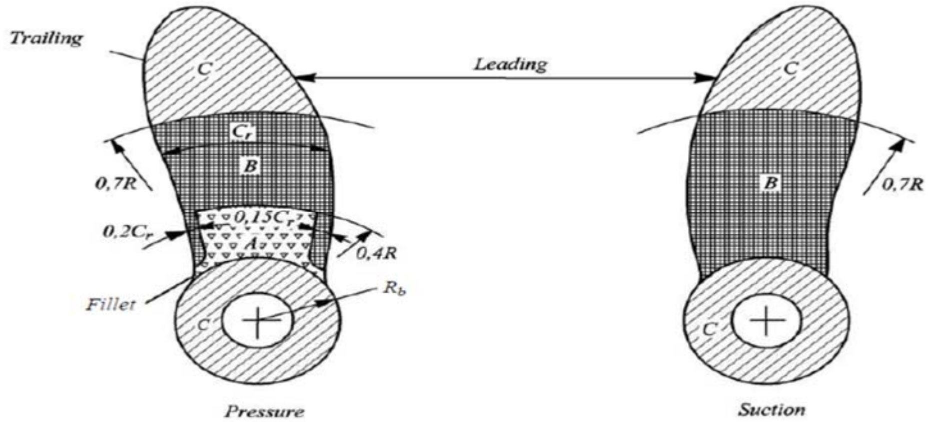


Fig. 4.2.6.2-1. Severity zones for integrally cast low skew propellers, where R – screw radius, C_r – chord length at any radius

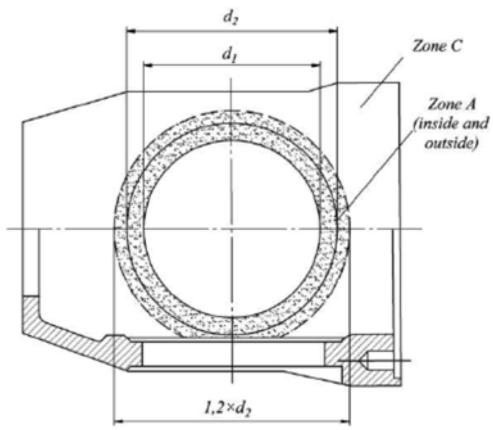


Fig. 4.2.6.2-2. Severity zones for controllable pitch propeller boss

4.2.6.4 *Zone A* is a region characterized by the highest operating stresses and the greatest thicknesses, and therefore it requires the highest degree of inspection and performance of all repair works.

Zone B is also a region where the operating stresses may be high, and therefore welding shall preferably be avoided in repair works.

Zone C is a region, in which the operating stresses are low and where the blade thicknesses are relatively small.

Repair welding is safer and is permitted in accordance with a procedure approved by the Register.

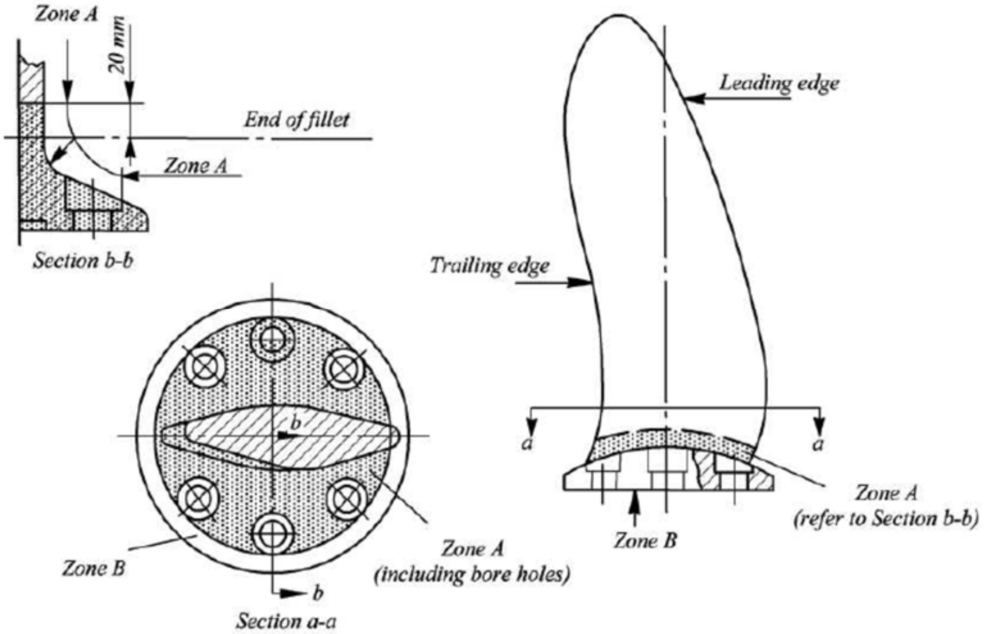


Fig. 4.2.6.2-3. Severity zones for controllable pitch and built-up propeller

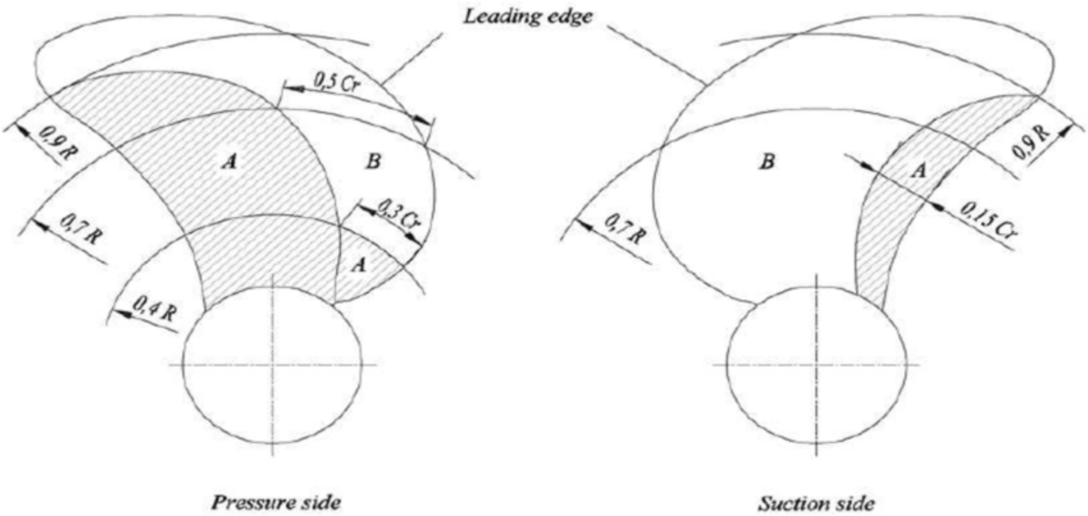


Fig. 4.2.6.3. Severity zones in blades with skew angles greater than 25°

4.2.7 Inspection.

4.2.7.1 Propeller castings shall be visually tested at all stages of manufacture. The castings shall be subjected to a comprehensive visual testing in the finished condition by the surveyor to the Register. At the final stage of manufacture the inspection shall include the bore. The castings subject to inspection shall be fettled and their surface prepared for non-destructive testing. The surface shall be free from defects liable to result in damage of propellers in the course of operation.

Note: Casting defects, which may impair the serviceability of the castings, e.g. major non-metallic inclusions, shrinkage cavities, blow holes and cracks, are not permitted. These defects may be removed by one of the methods described in **4.2.8** and repaired within the limits and restrictions for the severity areas. Full description and documentation shall be presented to the surveyor to the Register before commencement of works.

4.2.7.2 The dimensions and the dimensional and geometrical tolerances shall comply with the requirements of the drawings approved by the Register and order documentation. The above documents and the results of measurements and inspection drawn up in the form of a report shall be submitted to the surveyor to the Register at the time of the test. Unless expressly provided otherwise, the accuracy and verification of the dimensions are the responsibility of the manufacturer. Static balancing shall be carried out on all the propellers in accordance with the documentation approved by the Register.

Dynamic balancing is necessary for propellers running above 500 rpm.

4.2.7.3 Non-destructive testing.

4.2.7.3.1 Penetrant testing.

The severity zones *A* (refer to 4.2.6) shall be subjected to penetrant testing in the presence of the surveyor to the Register. In zones *B* and *C* the penetrant testing shall be performed by the manufacturer and may be witnessed by the surveyor. If repairs have been made either by grinding or by welding the repaired areas shall be additionally subjected to penetrant testing independent of their location and/or severity zone. The penetrant testing shall be carried out in accordance with a standard or specification approved by the Register. The following definitions shall be applied.

Indication is the presence of detectable bleed-out of the penetrant from the material discontinuities appearing at least 10 min after the developer has been applied. The shape of indications shall be determined in accordance with Fig. 4.2.7.3.1.

Reference area is an area of 100 cm^2, which may be square or rectangular with the major dimension not exceeding 250 mm.

For evaluation of surface quality by penetrant testing method the entire surface to be inspected shall be divided into reference area. The area shall be taken in the most unfavourable locations relative to the indication being evaluated i.e. the shape and dimensions of each reference area are chosen so that they cover the maximum number of defects without their distribution to an adjacent reference area.

The indications detected in each of such areas are, with respect to their size and number, shall not exceed the values given in Table 4.2.7.3.1.

Areas, which are prepared for welding, shall, independent of their location, always be assessed according to zone A. The same applies to the welded areas after being finished machined and/or grinded.

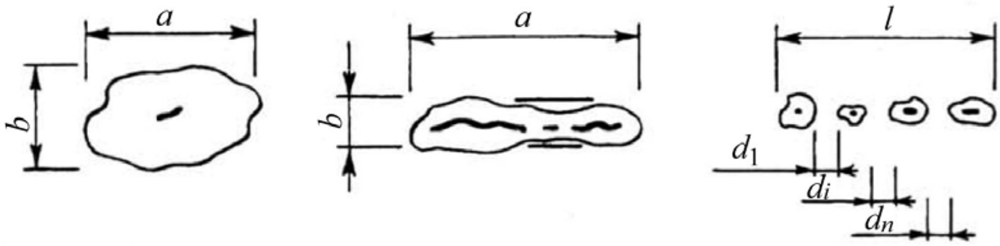
4.2.7.3.2 Контроль радіографічний і ультразвуковий.

Radiographic and ultrasonic testing.

Where serious doubts exist that the castings are not free from internal defects further radiographic and/or ultrasonic testing shall be carried out. The evaluation and acceptance criteria shall be agreed as part of the documentation of the manufacturer and/or the standards recognized by the Register.

It shall not beed that the absorption of the X-rays and gamma-rays is stronger in copper-base alloys than in a steel. For propeller bronzes, 300 kV X-rays can normally be used up to 50 mm and Co 60 gamma-rays up to 160 mm thickness. Due to the limited thicknesses that can be radiographed as well as for other practical reasons radiographic testing is generally not a suitable method for checking of the thickest parts of large propellers.

As a general rule, ultrasonic testing of CU1 and CU2 is not feasible due to the high damping capacity of these materials. For CU3 and CU4, ultrasonic testing of subsurface defects is possible.



1. $a/b < 3$ 2. $a/b \geq 3$ 3. $0 < d_i \leq 2$ mm

Fig. 4.2.7.3.1. Shape of indications: 1 – circular; 2 – linear; 3 – aligned

***Table 4.2.7.3.1.* Allowable number and size of indications in a reference area of 100 cm^2, depending on the severity zones**

Severity zones	Max. total number of indications	Type of indication	Max. number of each type of indications	Dimension *a* or *l*
A	7	circular	5	4
		linear	2	3
		aligned	2	3
B	14	circular	10	6
		linear	4	6
		aligned	4	6
C	20	circular	14	8
		linear	6	6
		aligned	6	6

Notes: 1. Singular circular idications less than 2 mm for zone A and less than 3 mm for the other zones may be disregarded. 2. The total number of circular indications may be increased to the maximum total number represented by the absence of linear/aligned indications. The total number of circular indications may also be increased due to the absence of part of linear and/or aligned indications retaining the total number of allowable indications

4.2.8 Repair of defects.

4.2.8.1 Discontinuities of the surface causing indications when penetrant testing is carried out and not meeting the requirements of Table 4.2.7.3.1, such as cracks, shrinkage cavities, sand, slag and other non-metallic inclusions, blow holes, etc., which may impair the safe service of the propeller, shall be eliminated or welded.

Dimensions, number and location of defects allowable without repairs, as well as of those subject to repair shall be specified in the product documentation submitted to the Register for approval.

In general the repairs shall be carried out by mechanical means, e.g. by grinding, chipping or milling. Welding may be applied if the requirements stated here are complied with.

After milling or chipping grinding shall be applied for such defects, which shall not be welded. Grinding shall be carried out in such a manner that the contour of the ground depression is as smooth as possible in order to avoid stress concentrations or to minimize cavitation corrosion.

Welding of areas less than 5 cm^2 shall be avoided.

4.2.8.2 Repair of defects in zone *A*.

In zone A, repair welding is not allowed. Grinding shall be carried out to an extent, which maintains the blade thickness of the drawing approved by the Register.

4.2.8.3 Repair of defects in zone *B*.

Defects that are not deeper than $dB=t/40$ mm (t=minimum local thickness, in mm, according to the Rules) or 2 mm (whichever is greater) shall be removed by grinding. Those defects, which are deeper than allowable for removal by grinding, may be repaired by welding.

4.2.8.4 Repair of defects in zone *C*.

In zone *C*, repair welds are generally permitted.

4.2.8.5 Repair welding.

The welding procedure and welding consumables used in repair welding shall be recognized by the Register as required by Part XIV "Welding". Defects shall be repaired by welders of adequate qualification, allowed by the Register to perform such works.

The approval of the welding procedure shall be based on welding of samples as shown in Fig. 4.2.8.5-1, which shall be subjected to non-destructive testing (penetrant and radiographic testing).

As an alternative, tensile test specimens may be prepared in compliance with the methods approved by the Register or the recognized standards.

The above works shall be performed by the manufacturer before commencement of welding operations.

Welding specification to be submitted to the Register for approval shall be made taking into account the following requirements and recommendations:

defects shall be repaired by mechanical means in accordance with **4.2.8**, using penetrant testing for determination of the complete removal of the defects;

selection of welding consumables, selection of preheat temperature and heat treatment temperature for stress relief shall be made in compliance with the requirements of Table 4.2.8.5-1. It shall noted that with the exception of alloy CU3 all weld repairs shall be stress relief heat treated, in order to avoid stress corrosion cracking;

where stress relief heat treatment of alloy CU3 propeller castings is required after major repairs in zone B and/or zone *A* or if a welding consumable susceptible to stress corrosion cracking is used, the propeller shall be either stress relief heat treated in the temperature 450 to 500°C or annealed in the temperature range 650 to 800°C depending on the extent of repair (refer to Table 4.2.8.5-1);

the defects shall be repaired as far as possible in the down-hand position, using arc welding with coated electrodes or "wire - shielded gas" combination.

Where the down-hand position is impossible for repairs, only "wire - shielded gas" combination shall be used;

Note: Use of argon-shielded tungsten welding is not recommended due to the higher specific heat input of this process.

for CU1 and CU2 materials having a thickness 30 mm and less gas welding may give a satisfactory weldment;

the time of conditioning for stress relief heat treatment of copper alloy propellers is determined in accordance with Table 4.2.8.5-2. The cooling rate shall not exceed 50 8C/h until the temperature of 200°C is reached.

Table 4.2.8.5.1-1. **Recommended filler metals and heat treatments**

Alloy type	Filler metal	Preheat temperature, °C, min	Interpass temperature, °C, max	Stress relief temperature, °C	Hot straightening temperature, °C
CU1	Al-bronze[1]	150	300	350–550	500–800
	Mn-bronze	150	300	350–550	500–800
CU2	Al-bronze	150	300	350–550	500–800
	Ni-Mn-bronze	150	300	350–550	500–800
CU3	Al-bronze	50	250	450–500	700–900
	Ni- Al-bronze[2]	50	250	450–500	700–900
	Mn- Al-bronze	50	250	450–500	700–900
CU4	Mn- Al-bronze	100	300	450–600	700–850

[1] Ni-Al-bronze and Mn-Al-bronze are acceptable.
[2] Stress relieving is not required.

4.2.8.6 Straightening.

For hot and cold straightening, static loading only shall be used.

Straightening of a bent propeller blade or pitch modification shall be carried out after heating the bent region and approximately 500 mm wide zones on either side of it. The temperature range shall comply with the requirements of Table 4.2.8.5-1; the heating shall be slow and uniform.

Table 4.2.8.5.1-2. Table

Stress relief temperature , °C	Alloy grade CU1 and CU2		Alloy grade CU3 and CU4	
	Hours per 25 mm thickness	Max. recommended total time, hours	Hours per 25 mm thickness	Max. recommended total time, hours
350	5	15	–	–
400	1	5	–	–
450	0,5	2	5	15
500	0,25	1	1	5
550	0,25	0,5	0,5[1]	2[1]
600	–	–	0,25[1]	1[1]

[1] 550 and 600°C only applicable to CU4 alloys

Table 4.2.8.5.1-3. **Required tensile strength values for coppre-base alloys welded joints**

Alloy type	Tensile strength, MPa
CU1	370
CU2	410
CU3	500
CU4	550

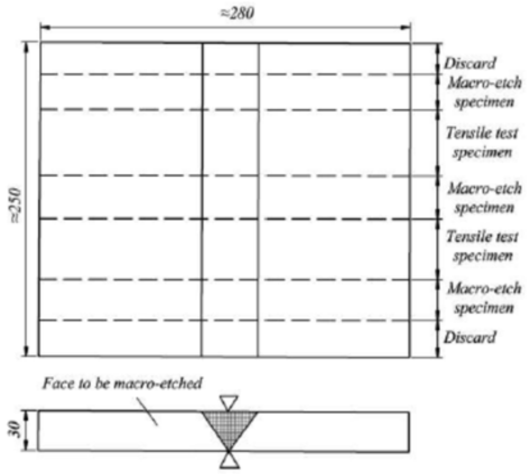


Fig. 4.2.8.5.1-1

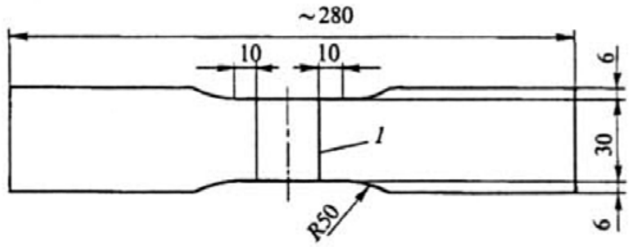


Fig. 4.2.8.5.1-2. Tensile test specimen: 1 – weld edge

The concentrated flame such as oxy-acetylene and oxy-propane shall not be used. Cold straightening shall be used for minor repairs of tips and edges only.

Cold straightening on CU1 and CU2 as well as CU4 bronze shall be always followed by a stress relieving heat treatment in accordance with Table 4.2.8.5-1.

4.2.9. Identification and marking.

4.2.9.1 Identification.

The manufacturer's shall employ a monitoring system, which enables all castings to be traced back to their heat. The confirmation of the availability of such system at manufacturer's shall be given during the manufacturer's survey.

4.2.9.2 Marking.

Marking shall be made in compliance with the requirements of 1.4. Besides, marking shall contain the following data:

number of the Register Certificate;

skew angle for high-skew propellers;

ice class symbol, where applicable.

4.2.9.3 The Manufacturer's Certificate to be submitted to the surveyor to the Register shall contain the following details:

purchaser and order number;

shipbuilding project number, if known;

description of the casting with drawing number;

diameter, number of blades, pitch, direction of turning;

grade of alloy and chemical composition of each heat;

heat and casting number;

final weight;

results of non-destructive tests, if used;

portion of alpha phase for CU1 and CU2 alloys;

results of the mechanical tests;

casting identification number;

skew angle for high-skew propellers.

5. ALUMINIUM ALLOYS

5.1 WROUGHT ALUMINIUM ALLOYS

5.1.1 General.

The present requirements apply to semi-finished products of wrought aluminium alloys (plates, sections, panels etc.) of 3 to 50 mm in thickness intended for ship hulls, superstructures and other marine constructions. Generally, the requirements for aluminium alloys designed for the structures, cargo storage systems of the gas carriers and/or operating at low cryogenic temperatures are given in **10.2.3**.

Designation of aluminium alloys is based on the designations of the Aluminium Association. Designation of national alloys approved by the Register is given in accordance with the Russian standards.

The use of wrought aluminium alloys that do not comply with the present requirements in terms of chemical composition, mechanical properties or the condition of delivery may be allowed in case the data on alloy properties, corrosion resistance welding technology features, as well as the alloys' behavior in the working conditions, are provided. Normative technical documentation and/or respective standards shall be submitted to the Register for approval.

Alloys shall be recognized by the Register in accordance with **1.3.2.1**.

All aluminium alloys shall be manufactured under the technical supervision of the Register at the firms recognised by the Register in accordance with **1.3.1**. The material complying with the Register requirements shall be supplied with the Register certificates and marks.

Manufacturers' Certificates for ingots, slabs and billets with the indication of the manufacturer's name, alloy grade, number of cast and chemical composition shall be available to the surveyor performing survey at the enterprise with no melting facilities. Information about the system, which is capable of ingot, slab and billet identification, shall be provided.

The enterprise, which performs aluminium alloys melting, shall be approved by the Register.

The requirements of this Part apply to the following aluminium alloys:

.1 rolled products (plates, strips and sheets):
5083, 5086, 5383, 5059, 5754, 5456;
temper conditions: O/H111/H112/H116/H321;
national alloys: 1530, 1550, 1561, 1561H, 1565ч, 1575;
temper conditions: O/H111/H112, H32/H321;

.2 pressed sections (full sections, hollow sections, panels, angles and bars etc.):
5083, 5383, 5059, 5086;
temper conditions: O, H111, H112, and 6005A, 6061, 6082;
temper conditions: T5, T6;
national alloys: 1530, 1550, 1561, 1561H, 1565ч, 1575;
temper conditions: O/H111/H112.

Alloys 6005A, 6061 and 6000 series shall not be used in direct contact with sea water unless protected by anodes and/or coating system.

5.1.2 Chemical composition.

The chemical composition of wrought aluminium alloys determined for each cast shall meet the requirements of Table 5.1.2. Samples for testing of chemical composition shall be blanked directly from the semi-finished products (plates, panels, etc.).

5.1.3 Mechanical properties.

Mechanical properties of wrought aluminium alloys shall meet the requirements of Tables 5.1.3-1 and 5.1.3-2.

5.1.4 Condition of supply.

Condition of supply shall be specified in accordance with ДСТУ EN 515 or the applicableEN standard or other international and national standards recognized by the Register.

National aluminium wrought alloys shall be delivered with indication of condition of supply in accordance both with ДСТУ EN 515, and applicable national standards.

Таблиця 5.1.2. **Chemical composition**

Grade	**A1, %**	**Si, %**	**Fe, %**	**Cu, %**	**Mn, %**	**Mg, %**	**Cr, %**	**Zn, %**	**Ti, %**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
5083	Base	≤0,40	≤0,40	≤0,10	0,4–1,0	4,0–4,9	0,05–0,25	≤0,25	≤0,15
5383	Base	≤0,25	≤0,25	≤0,20	0,7–1,0	4,0–5,2	≤0,25	≤0,40	≤0,15
5059	Base	≤0,45	≤0,50	≤0,25	0,6–1,2	5,0–6,0	≤0,25	0,4–0,9	≤0,20
5086	Base	≤0,40	≤0,50	≤0,10	0,20–0,7	3,5–4,5	0,05–0,25	≤0,25	≤0,15
5754	Base	≤0,40	≤0,40	≤0,10	≤0,50[2]	2,6–3,6	≤0,30	≤0,20	≤0,15
6005A	Base	0,50–0,90	≤0,35	≤0,30	≤0,50[3]	0,04–0,7	≤0,30[3]	≤0,20	≤0,10
6061	Base	0,40–0,80	≤0,70	0,15–0,40	≤0,15	0,8–1,2	0,04–0,35	≤0,25	≤0,15
6082	Base	0,70–1,30	≤0,50	≤0,10	0,4–1,0	0,6–1,2	≤0,25	≤0,20	≤0,10
National alloys									
1530	Base	0,50–0,80	≤0,50	≤0,10	0,30–0,60	3,2–3,8	≤0,05	≤0,20	≤0,10
1550	Base	≤0,50	≤0,50	≤0,10	0,30–0,80	4,8–5,8	–	≤0,20	≤0,10
1561	Base	≤0,40	≤0,40	≤0,10	0,70–1,10	5,5–6,5	–	≤0,20	–
1561H	Base	≤0,40	≤0,40	≤0,10	0,50–0,80	5,5–6,5	–	≤0,20	–
1575	Base	≤0,20	≤0,30	≤0,10	0,35–0,60	5,4–6,4	0,05–0,15	≤0,01	≤0,07
1565ч	Base	≤0,20	≤0,30[6]	0,05–0,1	0,4–1,2	5,1–6,2[7]	0,02–0,25	0,45–1	≤0,10

Continue of Table ***5.1.2***

Grade	**Other elements, %**		**Note**
	Each	Total[1]	
1	**11**	**12**	**13**
5083	≤0,05	≤0,15	–
5383	≤0,05[4]	≤0,15[4]	–
5059	≤0,05[5]	≤0,15[5]	–
5086	≤0,05	≤0,15	–
5754	≤0,05	≤0,15	0,10≤Mn + Cr≤0,60
6005A	≤0,05	≤0,15	0,12≤Mn + Cr≤0,50
6061	≤0,05	≤0,15	–
6082	≤0,05	≤0,15	–
National alloys			
1530	≤0,05	≤0,15	–
1550	≤0,05	≤0,15	–
1561	≤0,05	≤0,15	Zr (0,02–0,12)
1561H	≤0,05	≤0,15	Zr (0,10–0,17)
1575	≤0,05	≤0,15	Zr (0,10–0,12)
1565ч	≤0,05	≤0,15	Zr (0,08–0,13), Ni(0,05)

[1] Including Ni, Ga, V and other elements not given here.
[2] Mn +Cr : 0,10 – 0,60.
[3] Mn +Cr : 0,12 – 0,50.
[4] Zr: maximum 0,20. The total for other elements does not include Zirconium.
[5] Zr: 0,05 – 0,25. The total for other elements does not include Zirconium.
[6] Fe + Ni: ≤0,70.
[7] Mg + Zn: 5,7 – 7,3.

The parameters of thermal and thermomechanical treatment providing alloys properties are determined by semi-finished products manufacturer.

Condition of supply is specified in the Manufacturer's Certificate for semi-finished product.

5.1.5 Sampling.

Samples for mechanical properties determining shall be taken so that the longitudinal axis of the test specimen is oriented as follows:

for rolled products, as a rule, – across the direction of rolling. If the width of rolled products is insufficient for cutting off of specimens or if their are special national standards – the production of longitudinal samples is allowed;

for pressed sections (full sections, hollow sections, bars etc.) –along the main axis of the semifinished product;

Table 5.1.3-1. **Mechanical properties for rolled products**

Grade	Temper condition	Yield stress, $R_{p0,2}$, min, MPa[3]	Tensile strength, R_m, MPa[3]	Thickness t, mm	Elongation, %, min.	
					A_{50mm}	A_{5d}
5083	O/H111	125	275–350	$3 \le t \le 50$	16	14
	H112	125	275		12	10
	H116	215	305		10	10
	H321	215-295	305-385		12	10
5383	O/H111	145	290	$3 \le t \le 50$		17
	H116	220	305		10	10
	H321	220	305		10	10
5059	O/H111	160	330	$3 \le t \le 50$	-	24
	H116	270	370	$3 \le t \le 20$	10	10
		260	360	$20 < t \le 50$	10	10
	H321	270	370	$3 \le t \le 20$	10	10
		260	360	$20 < t \le 50$	10	10
5086	O/H111	95	240 - 305	$3 \le t \le 50$	16	14
	H112	125	250	$3 \le t \le 12,5$	8	
		105	240	$12,5 < t \le 50$		9
	H116	195	275	$3 \le t \le 50$	10 [2]	9
5754	O/H111	80	275	$3 \le t \le 50$	18	17
5456	O/H111	130 - 205	290 - 365	$3 \le t \le 6,3$	16	
		125 - 205	285 - 360	$6,3 < t \le 50$	16	14
	H116	230	315	$3 \le t \le 30$	10	10
		215	305	$30 < t \le 40$		10
		200	285	$40 < t \le 50$		10
	H321	230 - 315	315 - 405	$3 \le t \le 12,5$	12	
		215 - 305	305 - 385	$12,5 < t \le 40$		10
		200 - 295	285 - 370	$40 < t \le 50$		10
National alloys						
1530	O/H112	80	185	$3 \le t \le 12,5$	15	
		60	165	$12,5 < t \le 50$		11
1550	O/H112	125	275	$3 \le t \le 12,5$	15	
		110	255	$12,5 < t \le 50$		12
1561	O/H112	175	335	$3 \le t \le 12,5$	12	
		175	335	$12,5 < t \le 50$		10
1561H	H32/H321	245	355	$3 \le t \le 12,5$	10	
		225	335	$12,5 < t \le 50$		12
1575	O/H112	295	400	$3 \le t \le 12,5$	11	
1565ч	O/H112	145	330	$2 \le t \le 4$		18
		170	330	5		15
		175	335	$5,5 < t \le 10,5$		15
		175	335	$11,0 < t \le 40$		15
		175	330	$40 < t \le 60$		15
		170	310	$60 < t \le 80$		12

Notes: 1. The values in the Table are applicable for longitudinal and transverse specimens as well.
2. 8 % for thicknesses up to and including 6,3 mm.
3. The mechanical properties for the O and H111 tempers are the same. However, they are separated to discourage dual certification as these tempers represent different processing;

for pressed sections for welding of hollow sections - perpendicular to the section axis.

The samples shall be taken at one third of the width from a longitudinal edge of rolled products.

In the range 1/3 to 1/2 of the distance from the edge to the centre of the semi-finished product samples shall be taken at the thickest part of it.

***Table 5.1.3-2*. Mechanical properties for extruded products**

Grade	**Temper condition**	**Yield stress, $R_{p0,2}$, min, MPa[3]**	**Tensile strength, R_m, MPa[3]**	**Thickness t, mm**	**Elongation, %, min.**	
					A_{50mm}	A_{5d}
5083	O	110	270 - 350	$3 \le t \le 50$	14	14
	H111	165	275		12	10
	H112	110	270		12	10
5383	O	145	290	$3 \le t \le 50$	17	17
	H111	145	290		17	10
	H112	190	310			10
5059	H112	200	330	$3 \le t \le 50$	–	10
5086	O	95	240 - 315	$3 \le t \le 50$	14	14
	H111	145	250		12	
	H112	95	240		12	9
6005A	T5	215	260	$3 \le t \le 50$	9	–
	T6	215	260	$3 \le t \le 10$	8	14
		210	250	$10 < t \le 50$	8	10
6061	T6	240	260	$3 \le t \le 50$	10	8
6082	T5	230	270	$3 \le t \le 50$	8	10
	T6	250	290	$3 \le t \le 5$	6	
		260	310	$5 < t \le 50$	10	10
National alloys[1]						
1530	O/H111/H112	80	175	$3 \le t \le 12{,}5$	12	
				$12{,}5 < t \le 50$		12
1530	O/H111/H112	125	255	$3 \le t \le 12{,}5$	13	
				$12{,}5 < t \le 50$		13
1561	O/H111/H112	205	335	$3 \le t \le 12{,}5$	11	
				$12{,}5 < t \le 50$		11
1575	O/H111/H112	295	400	$3 \le t \le 12{,}5$	11	
				$12{,}5 < t \le 50$		11
1565ч	O/H 112	185	335	$3 \le t \le 12{,}5$		12
		185	335	$5{,}5 < t \le 50$		12

[1] The mechanical properties specified for national alloys also cover hollow sections made of these alloys if their crosssection does not exceed 60 mm^2 or the diameter of a circumscribed circle is equal or less than 250 mm.

Note. The values in the Table are applicable for longitudinal and transverse specimens as well

Blanking of specimens as well as production of specimens for tests shall be made by the methods preventing the possible change of alloys properties because of hardening.

Each specimen shall be marked so that after its manufacture and cleaning it is posssible to identify it with the specific semi-finished product and to determine the place where it was blanked and orientation of it.

The requirements for tensile test specimens are set forth in **2.2.2.5**, and the general requirements for the tests — in **2.1**.

5.1.6 Scope of testing.

Semi-finished products of wrought aluminium alloys are submitted for testing in batches.

A batch shall consist of semi-finished products of the same grade (the same cast), of the same form and dimensions (for plates - of the same thickness), of the same temper condition and manufactured by the same technological process.

5.1.6.1 Rolled products.

One tensile test specimen is taken from each 2000 kg. If the weight of the batch exceeds 2000 kg, one extra tensile testing shall be carried out for each 2000 kg (full or not).

For plates, strips or coils weighting more than 2000 kg each, only one tensile test specimen shall be taken.

5.1.6.2 Pressed sections (full sections, hollow sections, bars etc.).

One tensile test specimen shall be taken from each batch:

of 1000 kg - for products weighting less than 1 kg;

of 2000 kg - for products weighting from 1 to 5 kg;

of 3000 kg - for products weighting more than 5 kg.

If the weight of semi-finished products batch exceeds the specified figures, an additional testing shall be carried out for each batch (full or not).

If the test results are unsatisfactory, the testing shall be repeated in accordance with the requirements of **1.3.5**.

5.1.7 Quality testing of welded joints of hollow sections made by welding.

The manufacturer shall carry out macrosection tests and drift expansion tests confirming that there is no lacks of fusion in each batch of closed sections.

Sections for testing shall be submitted in batches consisting of no more than five semi-finished products. One section from each batch is submitted to testing. If the lengths of sections exceed 6 m every semi-finished product shall be tested.

The length of specimens shall comply with **2.2**. The test samples from each semi-finished product submitted to testing shall be cut from the each end perpendicular to the axis of the section. In any case the length of the specimen shall not be less than 50 mm.

Drift expansion testing shall be carried out at ambient temperature by means of a hardened steel conical mandrel (of at least 60°).

Testing is considered unsatisfactory if the specimen fails with a clean split along the weld line, which confirms lack of fusion.

5.1.8 Corrosion testing.

Rolled alloys of type 5083, 5383, 5059, 5086 and 5456 in H116 and H321 tempers intended for use in marine hull construction or in marine applications where frequent direct contact with seawater is expected shall be corrosion tested in the above medium with respect to exfoliation and intergranular corrosion resistance.

During the initial works survey for the purpose of its recognition, the manufacturer shall provide data concerning the relationship between microstructure and resistance to corrosion.

Reference photomicrographs taken at 500X (according to provisions in ASTM B928, Section 9.4.1), shall be established for each of the alloy-tempers and thickness ranges relevant. The reference photographs shall be taken from samples, which have exhibited no evidence of exfoliation corrosion and a pitting rating of PB or better, when subjected to the test described in ASTM G66 (ASSET). The samples shall also have exhibited resistance to intergranular corrosion at a mass loss no greater than 15 mg/cm^2, when subjected to the test described in ASTM G67 (NAMLT). The tests for exfoliation corrosion and intergranular corrosion may be conducted in accordance with other national standards recognized by the Register.

The documentation (reports) relating to the test results and the established relationship between microstructure and resistance to corrosion submitted by the manufacturer shall be approved by the Register. Any changes in production practices of the material shall require respective examinations to be carried out and documentation exhibiting evidence of alloy corrosion resistance to be reapproved.

For rolled alloys of type 5083, 5383, 5059 and 5086 in the H116 and H321 tempers, comparative metallographic examination of one sample selected from mid width at one end of a batch coil (semifinished product) shall be carried out.

A longitudinal section perpendicular to the rolled surface shall be prepared for comparative metallographic examination. If the microstructure shows evidence of continuous grain boundary network of aluminium-magnesium precipitate in excess of the metal tested at the initial approval, the batch shall either be rejected or, at the discretion of the Register, tested for exfoliation-corrosion resistance and intergranular corrosion resistance. The methods and assessment criteria of corrosion resistance test results shall be in accordance with ASTM G66 and G67 or the standards recognized by the Register. Acceptance criteria are that the sample shall exhibit no evidence of exfoliation corrosion and a pitting rating of PB or better when test subjected to ASTM G66 ASSET test, and the sample shall exhibit resistance to intergranual corrosion at a mass loss no greater than 15 mg/cm^2 when subjected to ASTM G67 NAMLT test.

If the results from testing satisfy the above criteria, the batch is accepted.

As an alternative to metallographic testing, each batch may be tested for exfoliation-corrosion resistance and intergranular corrosion resistance, in accordance with ASTM G66 and G67 under the conditions specified in ASTM B928, or the equivalent standards recognized by the Register. If this alternative is used, then the results of the test shall satisfy the acceptance criteria stated in **5.1.8**.

5.1.9 Inspection.

Semi-finished products of wrought aluminium alloys prepared for delivery shall have no internal and external defects negatively affecting their direct use.

All semi-finished products are liable to visual testing.

The application of non-destructive testing is not required if not specially indicated. Still it is supposed that manufacturers use the required non-destructive testing during manufacturing of wrought aluminium alloys in order to maintain products quality at the appropriate level.

It is allowed to rectify the detected surface defects by grinding or flogging provided this corrections doesn't change the size of semi-finished products out of the allowed tolerances.

Ultimate negative thickness tolerances for rolled aluminium alloys are given in Table 5.1.9. Rolling with tolerances in compliance with recognized national or international standards is allowed.

Ultimate negative thickness tolerances for pressed semi-finished products shall be in compliance with the requirements of recognized international or national standards.

Manufacturer of the material is responsible for dimensions of semi-finished products and the appropriate allowed tolerances.

Table 5.1.9. **Ultimate negative thickness tolerances for rolled products**

Nominal thickness *t*, mm	**Ultimate tolerances in relation to rolled products thickness, *S*, mm**		
	$S \le 1500$	$1500 < S \le 2000$	$2000 < S \le 3500$
$3 \le t \le 4$	0,10	0,15	0,15
$4 < t \le 8$	0,20	0,20	0,25
$8 < t \le 12$	0,25	0,25	0,25
$12 < t \le 20$	0,35	0,40	0,50
$20 < t \le 50$	0,45	0,50	0,65

5.1.10 Marking.

The main requirements for marking are set out in **1.4**.

Each semi-finished product shall be clearly identified by the agreed method and in the agreed place by the marks of the manufacturer and the Register.

Marking shall include as a minimum:

name and/or identification of the manufacturer;

alloy grade and temper conditions in accordance with the requirements of this Chapter;

batch number, semi-finished product number and identification number in accordance with the system adopted by the enterprise to trace back the whole production process.

It is allowed to put marks on labels if semi-finished products are delivered in bundles.

5.1.11 Documents.

Each batch or semi-finished product (if products are delivered in pieces) tested in accordance with 5.1.6, shall have the Manufacturer's Certificate and Register Certificate. As a minimum, the Manufacturer's Certificate shall contain the following:

order number;

construction of the ship or floating facility number, when known;

name, number, dimensions and weight of the semi-finished product;

alloy designation (grade) and temper condition;

batch number or semi-finished product number, or identification number, which allows to identify the material delivered.

The results of chemical analysis, mechanical tests and corrosion tests (if any) are the mandatory supplement to the Manufacturer's Certificate. The results of those tests shall confirm the material compliance with the Register requirements.

5.2 CAST ALUMINIUM ALLOYS

5.2.1 General.

The requirements of this Chapter apply to parts and structures of cast aluminium alloy used in hull and ship machinery structures and manufactured under survey by the Register.

Semi-finished products of cast aluminium alloys shall be manufactured at works recognized according to **1.3.1.4**.

5.2.2 Chemical composition and mechanical properties.

The chemical composition and mechanical properties of items cast of aluminium alloys shall meet the requirements of Table 5.2.2.

When chill or pressure casting is employed, mechanical characteristics values may exceed the specified ones.

The use of alloys with chemical composition and mechanical properties differing from those indicated in Table 5.2.2 may be allowed in accordance with national and international standards recognized by the Register.

***Table 5.2.2*. Chemical composition and mechanical properties of cast aluminium alloys**

Grade	**Chemical composition, %**		**Condition of supply**	**Mechanical properties, min**			
	Basic elements	Allowable residual elements (max)		$R_{p0,2}$, MPa	R_m, MPa	A_5, %	HB
1	Mg – 2,0...4,5 Si – 0,05...1,3 Mn–0,05...0,6 Al – remainder	Cu – 0,10 Fe – 0,50 Zn – 0,20 Ti – 0,20	Untreated	70	140	3	50
			Solution-treated with slow cooling down	125	210	1	65
2	Mg – 4...6 Si – 0,5...1,3 Mn–0,05...0,5 A1– remainder	Cu – 0,10 Fe – 0,50 Zn – 0,10 Ti – 0,20	Untreated	80	150	2	55
3	Mg – 9...11,5 Si – max 1,3 Mn – max 0,4 Al – remainder	Cu – 0,10 Fe – 0,50 Zn – 0,10 Ti – 0,15	Solution-treated and hardened	145	270	8	60
4	Si – 7...11 Mg – max 0,5 Mn– 0,15..0,5 Al – залишок	Cu – 0,10 Fe – 0,60 Zn– 0,30 Ti – 0,15	Untreated	90	150	2	50
			Solution-treated with slow cooling down	165	200	1,5	70
5	Si – 10...13,5 Mn – max 0,5 Al – remainder	Cu – 0,10 Fe – 0,60 Zn – 0,30 Ti – 0,15	Untreated	70	150	2	50
			Solution-treated and hardened	80	160	3	50

The new alloys with modified chemical composition not complying with the present requirements may be allowed in case the data on their properties, including corrosion resistance and application in the working conditions, are provided.

5.2.3 Heat treatment.

If castings of aluminium alloys are heat treated the type of heat treatment is chosen by the maker and recorded in the Manufacturer's Certificate for material.

5.2.4 Sampling.

The samples may be cast-on or separately cast. The sample thickness shall not be less than the minimum wall thickness of the casting.

Whenever possible, the cooling of the samples will be effected in conditions similar to the cooling of castings.

In the case of castings for parts operating under high loads the thickness of the samples shall not be less than the thickness of the highest loaded zone of the castings and it shall be specified in the drawing.

5.2.5 Scope of testing.

Depending on their application the castings of aluminium alloys shall be divided into test groups and tested accordingly within the scope indicated in Table 5.2.5.

***Table 5.2.5.* Test groups for cast aluminium alloys**

Test group	Conditions of application	Examples of application	Tests	Scope of testing	
				Batch size	**Number of tests**
I	Cast items subjected to loads and exposed to corrosion	Parts of internal combustion engines, pumps, compressors, fans, valves	Determination of chemical composition	Per cast	
			Tensile test	1 cast	2
II	Parts operating at high temperature and exposed to fuel oil, petroleum products, etc.	Pistons of internal combustion engines, compressors	Determination of chemical composition	Per cast	
			Tensile test	Each casting	1
			Hardness test		1

The scope of testing for castings with cast on samples shall be specified in the castings documentation submitted to the Register for approval.

Tensile tests are conducted to determine the yield stress, tensile strength and elongation.

When castings for small-size pistons are checked at the established manufacturing process and in the presence of the data confirming the continuous quality of castings, tensile tests of each batch may be omitted, in which case hardness tests shall be carried out.

5.2.6 Inspection.

The castings shall be submitted for inspection in the fettled condition with sprues, heads and burrs removed. They shall be free of any defects detrimental to their application and strength.

Surface defects within the dimensional tolerances may be either ignored or removed by machining.

Certain casting defects may be repaired by welding, the procedure of which shall be agreed with the Register.

If the material of the castings is tested for soundness by hydraulic pressure, the casting drawing shall contain information on the working pressure in the tested space and on the test pressure employed at testing.

The test pressure value is selected on the basis of the requirements of the relevant parts of the Rules.

Non-destructive testing may be conducted on castings intended for items, which operate under high loads.

5.2.7 Marking and documentation.

Identification, marking and issued documentation — in accordance with the requirements of **3.8.8**.

5.3 ALUMINIUM-STEEL LAMINATED COMPOSITE MATERIAL

5.3.1 General.

5.3.1.1 The present requirements apply to semi-finished products (plate, sheet, strip) of aluminiumsteel laminated composite material (aluminium-steel semi-finished products) intended for steel and aluminium joints of ship hulls, superstructures and other marine constructions as well as the ship machinery subject to the technical supervision of the Register in accordance with the requirements of other parts of the Rules.

5.3.1.2 Aluminium-steel semi-finished products shall be manufactured in compliance with the documentation approved by the Register at the enterprises recognized by the Register based on the requirements given in 1.3 and under technical supervision of the Register.

The Register representative performing technical supervision at the manufacturer of aluminium-steel semi-finished products with no metallurgical production of all the composite material components shall be provided with the Manufacturer's Certificates for basic materials. Suppliers of basic materials for aluminium-steel semi-finished product manufacture shall be recognized by the Register

5.3.1.3 The use of aluminium-steel semi-finished products based on wrought aluminium alloys and steel, which do not comply with these requirements in respect of chemical composition, mechanical properties or condition of supply will only be possible after thorough examination of material supply documentation, their actual properties, including corrosion resistance and welding procedure features. The data substantiating possible use of aluminium-steel semi-finished products under operating conditions shall be submitted to the Register.

5.3.1.4 Aluminium-steel semi-finished products may be manufactured by simultaneous hot rolling or explosion welding.

5.3.1.5 Aluminium-steel semi-finished products shall be manufactured not using cold or hot rolling as final operation to obtain the required thickness.

5.3.1.6 Hull structural steel, which complies with the requirements of **3.2**, is generally used as the base metal, steel layer of aluminium-steel semi-finished products. Rolled products (plate, sheet, strip) of alloys in annealed condition which comply with the requirements of **5.1**, e.g. 1561 and 5083 alloys, are used as aluminium layer of aluminium-steel semi-finished products.

In general, rolled steel and aluminium for aluminium-steel semi-finished products shall be manufactured by the enterprises recognized in accordance with 1.3 and under technical supervision of the Register.

5.3.1.7 Aluminium or primary commercial aluminium shall be used as the intermediate aluminium layer of aluminium-steel semi-finished products, shall be specified by the manufacturer and indicated in the documentation submitted for approval to the Register.

The nominal thickness of intermediate aluminium layer of aluminium-steel semi-finished products shall not be less than 0,25 mm.

The intermediate aluminium layer used for manufacture of aluminium-steel semi-finished product may be incorporated in the package as a separate layer or serve as a cladding on the basic aluminium layer of wrought aluminium-magnesium alloys.

Rolled products of wrought aluminium-magnesium alloys with single- or double-sided cladding of aluminium or primary commercial aluminium shall be specified by the manufacturer and indicated in the documentation submitted for approval to the Register.

The clad layer thickness on each side of the plate shall be not less than 4 % of the total plate thickness.

5.3.2 Chemical composition and mechanical properties.

The chemical composition and mechanical properties of basic materials as well as properties of aluminium-steel semi-finished products shall comply with the documentation approved by the Register. The chemical composition and mechanical properties of base materials intended for manufacture of aluminiumsteel semi-finished product shall comply with the requirements of **3.2** and **5.1**.

5.3.3 Condition of supply.

5.3.3.1 Aluminium-steel semi-finished products obtained by simultaneous hot rolling shall be supplied in annealed condition. Type and conditions of heat treatment shall be specified in the documentation submitted for approval to the Register.

5.3.3.2. Aluminium-steel semi-finished products obtained by explosion welding shall be supplied in initial condition.

5.3.4 Scope of testing.

5.3.4.1 The scope of testing and sampling of basic materials, steel and aluminium-magnesium alloys for aluminium-steel semi-finished products shall be in accordance with the requirements of **3.2** and **5.1**, accordingly.

5.3.4.2 During the initial survey for recognition of aluminium-steel semi-finished product manufacture by the Register according to **1.3.1**, the scope of testing shall be based on the program developed by the manufacturer of aluminium-steel semi-finished product and approved by the Register.

The control test program shall be developed to confirm the product quality stability and shall, as a minimum, include the following tests:

pull-off and shear tests to determine adhesion of test specimen layers in composite aluminium-steel material;

bend tests to determine plybond strength of test specimen layers in composite aluminium-steel material;

micro analysis of metal in the layer interface zone of composite aluminium-steel material.

Tests shall be carried out on a control batch. For each process stated (the same basic material supplier, the same size, the same condition of supply), 2 semi-finished products of a batch shall be submitted for testing.

Each semi-finished product of the control batch shall be subject to visual and ultrasonic testing to determine layer discontinuity zone.

Simultaneously with the test program, recommendations for welding aluminium-steel semi-finished products shall be submitted to the Register.

5.3.4.3 During manufacture, the scope of testing shall be determined on the basis of the material delivery documentation approved by the Register or the national/international standard recognized by the Register. Semi-finished products shall be submitted for testing in batches. A batch shall consist of semifinished products of the same condition of supply, the same size, manufactured by the same process and using basic materials received from the same supplier. In general, not less than 10 % of semi-finished products shall be taken from a batch with a mass of not more than 200 kg.

Where under the contract the delivered mass of aluminium-steel semi-finished products of the same size is considered to be a batch, not less than 20 % of semi-finished products in the batch shall be tested.

From each semi-finished product submitted for testing, samples shall be taken for pull-off and shear tests to determine layer adhesion.

Visual and ultrasonic testing to determine layer discontinuity zones shall be conducted on each semifinished product in the batch.

5.3.5 Sampling and testing.

5.3.5.1 During initial survey, the samples shall be taken from each end of semi-finished product.

During manufacture, the samples are generally taken from one end of the semi-finished product.

The samples shall be taken at a distance not less than 25 mm from the edge of the semi-finished product.

5.3.5.2 Bend tests to determine plybond strength of test specimen layers in composite aluminiumsteel material.

Bend test of bimetallic specimens shall be performed for the qualitative assessment of steel and aluminium layer plybond strength. No layer separation during bending shall be a performance criterion. Three test specimens shall be taken from a sample for bend test. One bend test shall be carried out with the specimen of the aluminium layer on the tensioned side and another with the specimen of the aluminium layer on the compressed side.

The third test specimen shall be subject to transverse bending (with the layers vertically oriented). Unless otherwise specified, the test conditions shall be in accordance with Table 5.3.5.2. The procedure for test specimens' preparation and test performance shall comply with the manufacturer's documentation approved by the Register, national and/or international standards.

Table 5.3.5.2 **Bend tests of aluminium-steel semi-finished products**

Test type	**Minimum bend, in deg.**	**Mandrel diameter**
Tensile test of aluminium	90	3*t*
Compression test of aluminium	90	3*t*
Transverse bending	90	6*t*
Note: *t* is the maximum semi-finished product thickness. Tests shall be carried out at room temperature.		

5.3.5.3 Pull-off and shear tests of aluminium-steel semi-finished product layer.

5.3.5.3.1 Pull-off and shear tests of aluminium-steel semi-finished product layers obtained by explosion welding.

The tests shall be carried out on one specimen of each type (pull-off and shear tests) taken near the place of explosion and on three specimens taken away from that area, one specimen (pull-off and shear tests) shall be taken from a remote end of the semi-finished product.

Pull-off and shear tests shal be carried out at the room temperature.

5.3.5.3.2 Pull-off and shear tests of aluminium-steel semi-finished product layers obtained by simultaneous hot rolling.

Pull-off and shear tests shall be carried out on one specimen of each type at the room temperature.

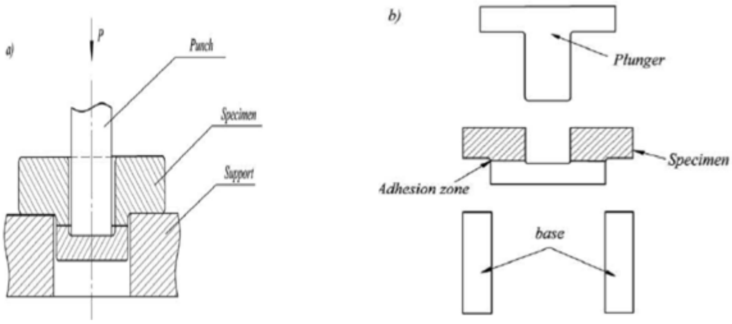


Fig. 5.3.5.3.2-1. Pull-off test diagrams (*a* or *b*)

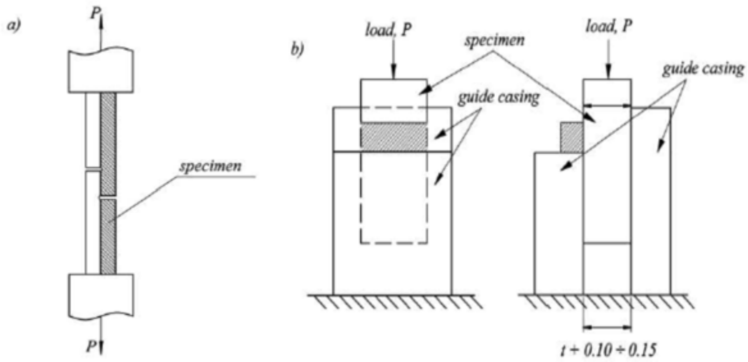


Fig. 5.3.5.3.2-2. Shear test diagrams (*a* or *b*)

Pull-off tests shall be carried out on specimens as shown in Fig. 5.3.5.3.2-1.

Shear tests shall be carried out on specimens as shown in Fig. 5.3.5.3.2-2.

For all the specimens tested, the ultimate pull-off and shear strength shall comply with the documentation approved by the Register.

Where the ultimate pull-off or shear strength of a laminated composite material is below the specified minimum, two additional pull-off and shear test specimens shall be tested.

Each new value shall not be less than the specified minimum value.

Where the ultimate pull-off or shear strength of a laminated composite material is below the specified minimum value but exceeds 70 % of the minimum value, two additional pull-off and shear test specimens taken from each end of the semi-finished product shall be tested.

Each new value shall not be less than the specified minimum value.

5.3.5.4 Visual and non-destructive testing.

5.3.5.4.1 Each aluminium-steel semi-finished product shall be subject to 100 % visual testing and ultrasonic testing to determine layer discontinuity zones.

5.3.5.4.2 The layer adhesion quality shall be determined by ultrasonic testing based on approved assessment criteria.

5.3.5.4.3 Micro structural analysis of interface between aluminium and steel layers of aluminiumsteel semi-finished products.

Manufacturer shall submit the photos of interface surface between the layers of composite material with x (10 ÷ 20) and x 100 magnification.

Micro structural analysis shall be made on the sections cut out of the samples for mechanical tests.

5.3.6 Inspection.

5.3.6.1 All aluminium-steel semi-finished products shall undergo surface inspection. Absence of defects not permitted under delivery documentation approved by the Register shall be guaranteed by the manufacturer, with a relevant entry to be made in the Manufacturer's Certificate.

The surface defects resulting from manufacturing procedure are permitted if their depth is within the negative deviations specified in the documentation.

It is allowed to rectify the detected surface defects by grinding or flogging, provided these corrections do not change the size of the semi-finished product out of the allowed tolerances. For aluminium-steel semi-finished products, repairing of surface defects of steel and aluminium layers is not permitted.

The responsibility for quality of control and maintenance of the required tolerances rests with the manufacturer.

5.3.7 Marking.

Marking is carried out in accordance with **5.1.10**. The basic requirements for marking are set forth in **1.4**.

Every semi-finished product shall have manufacturer's marking and the Register stamp clearly made in the specified manner and in a due place.

The marking shall include, as a minimum:

name and/or designation of the manufacturer;

grades of aluminium alloy and steel;

condition of supply;

number of a batch, semi-finished product or identification number according to manufacturer's system, which allows tracing complete production process.

If the semi-finished products are delivered in bundles, the marking may be made on tags.

5.3.8 Documents.

If supply is provided by piece, every batch of semi-finished product, which has undergone testing shall be provided with the Manufacturer's Certificate or Register Certificate. The Manufacturer's Certificate shall include, as a minimum:

order number;

construction project number, when known;

name, number, dimensions and weight of the semi-finished product;

alloy designation (grade) and temper condition;

batch number or semi-finished product number, or identification number, which allows to identify the material delivered.

The results of chemical analysis, mechanical tests and corrosion tests (if any) are the mandatory supplement to the Manufacturer's Certificate.

The results of those tests shall confirm the material compliance with the Register requirements.

If materials are supplied with the Manufacturer's Certificates witnessed by the Register representative, their form and contents shall be agreed with the Register and the customer.

5.3.9 Welding of semi-finished products of aluminium-steel laminated composite material.

5.3.9.1 Welded joints of aluminium-steel semi-finished products to steel and aluminium hull structural members shall be made by separate welding of layers between similar materials using fillet, overlap or butt welds.

5.3.9.2 Welding processes shall be approved in accordance with Sections **6** and **7**, Part XIV "Welding".

5.3.9.3 The edge preparation for welding shall be in accordance with the national standards and/or drawings approved by the Register.

The edge preparation shall be effected by machining or grinding. The edges of parts to be assembled shall fit each other closely and shall not be out of alignment on the internal side of steel layer.

5.3.9.4 Welding consumables for the steel layer shall be in accordance with the requirements of **4.2** and for the aluminium layer, with the requirements of **4.7**, Part XIV "Welding".

5.3.9.5 The weld shall be made first on the steel layer side and then on the aluminium layer side.

5.3.9.6 Welding on the steel layer side shall be so done that no melting of the aluminium layer forming part of the aluminium-steel semi-finished product occurs.

5.3.9.7 Prior to welding on the aluminium layer side, the weld root on the steel layer side shall be cut out to sound metal by machining or grinding only. Cutting out of the weld root by means of abrasive disks is not permitted.

5.3.9.8 Full-width of the edge preparation, high-alloyed welding consumables shall be deposited on the surface of welded edges of the steel layer to ensure good wetting when filling in the grooves with aluminium filler materials.

5.3.9.9 Immediately before welding (tack welding), the edges of aluminium alloy components shall be degreased with special solvents (acetone, alcohol, benzene, etc.) and then cleaned with wire brushes.

In the case of multirun welding, each run of deposit shall be brushed before the next run is applied.

5.3.9.10 Welding consumables of aluminium and aluminium alloys shall have their surfaces cleaned from dirt and oxide film.

5.3.9.11 When filling in the groove between the edges to be welded of the aluminium layer forming part of the aluminium-steel semi-finished products, unalloyed aluminium welding consumables shall be deposited by the first run.

Aluminium shall be deposited on steel surface on which high-alloyed welding consumables were deposited (refer to **5.3.9.8**) to avoid its mixing up with the steel layer metal.

5.3.9.12 Subsequent filling-in of the groove between the edges to be welded of the aluminium layer forming part of the aluminium-steel semi-finished products shall be effected with welding consumables in compliance with the requirements of **4.7**, Part XIV "Welding".

The weld on the aluminium layer side shall be made of two layers at least. In welding the aluminium layer, transverse weaving of electrodes is not permitted.

6. PLASTICS AND MATERIALS OF ORGANIC ORIGIN

6.1 GENERAL

6.1.1 This Section contains requirements for plastics and materials of organic origin used in hull and ship machinery structures for the manufacture of parts and structures, which are subject to survey by the Register.

The requirements of this Section may be also applied to plastics and materials of organic origin used in structures and products not normally surveyed by the Register, if their application has considerable effect on the safety of the ship as a whole.

As a rule, manufacture of all materials and items regulated by this Part shall be carried out in accordance with the documentation, approved by the Register, at works having the quality system approved by the Register and the Type Approval Certificate issued by the Register for the manufactured type of products.

Plastics, materials for gaskets and seals, as well as materials of organic origin used in ship devices, mechanisms, fittings and systems installed on open decks and in open spaces, which are not heated, on ships, shall meet the applicable requirements of **6**, Rart XIII "Materials", standards recognized by the Register and / or specification agreed with it. Additionally, documentary evidence of the reliable operation of these materials at the design temperature, or test reports of laboratories recognized by the Register, OCS or authorized state bodies, shall be submitted.

6.1.2 General.

All plastics and materials of organic origin shall satisfy the following requirements unless there are special provisions regarding them in the chapters of the Section:

.1 their combustibility, flame spread, ignatability and also by the volume of smoke and quantity of toxic substances shall be assessed in conformity with **1.6**, Part VI "Fire Protection";

.2 they shall ensure reliable operation of items and structures on the open deck at temperatures from -40 to +70°C and in the interior spaces of the ship at temperatures from -10 to +70°C unless their service conditions provide for lower or higher operating temperatures;

.3 they shall resist embrittlement and reduction of mechanical properties in service by more than 30 % in comparison with the original values;

.4 they shall resist decay and destruction by fungi and not to affect adversely the materials, with which they come into contact.

6.1.3 Scope of technical supervision.

6.1.3.1 The main provisions defining the scope and procedure of technical supervision are stipulated in **1.1.5** and **1.3**.

6.1.3.2 Technical supervision over manufacture of materials and products at works includes: review and analysis of the manufacturer's application with attachments thereto (refer to **6.1.3.2.2**);

survey of the works including the quality system assessment and control testing of products (refer to **6.1.3.2.3**);

issue of the Register Certificate (refer to **6.1.3.2.4**).

6.1.3.2.1 For the Register recognition of the company's products that comply with the requirements of the Rules, and to obtain the documents specified in **1.1.5**, the company shall apply to the Register with a appropriate application.

6.1.3.2.2 Application shall be supplemented by the following documents:

.1 information describing the works and its products (documents confirming the works status, its structure, production and control management schemes);

.2 list of manufactured materials and products;

.3 information on the staff of employees and their qualification;

.4 information on qualification of the personnel involved in the product quality system;

.5 information on availability of ДСТУ EN ISO 9001 or the applicable ISO or EN standards;

.6 information on available approvals by other classification societies and results of earlier tests, also data on practical application of materials and products indicated in the application confirming the possibility of their application for intended purpose;

.7 Quality Manual with description of quality policy;

.8 procedures and instructions describing production processes, sources of supply and stockyards of source materials, storage of finished products;

.9 data on periodical control equipment and devices employed in the process of production, as well as equipment of the works laboratory;

.10 specifications or other technical documents describing materials mentioned in the application and defining their main characteristics and conditions of manufacture;

.11 rules for safe utilization of materials or products;

.12 program of testing the specimens of materials or products compiled on the basis of requirements of these Rules.

6.1.3.2.3 If the results of consideration of the submitted documentation are positive, a survey of the manufacturer's works is undertaken; it is aimed at establishing the actual condition of organization and quality control processes including products manufacture, as well as control tests in accordance with the program approved by the Register.

If the tests of products in question cannot be conducted at the manufacturer's works, it can be done at a laboratory approved by the Register.

6.1.3.2.4 Where results of the manufacturer's and products survey are satisfactory, the Register Certificate for works and products is issued.

The validity of the Certificate of type approval and the procedure and conditions of its confirmation are determined upon its issuance, taking into account the assessment of the company quality system.

6.1.3.2.5 Delivery of products is carried out with a copy of the Certificate of type approval.

6.2 FIBER-REINFORCED PLASTICS

6.2.1 General.

The present requirements cover materials for the manufacture of fiber-reinforced plastics (FRP) for ship structures and products subject to the RU survey.

Requirements for fiber-reinforced plastics and their components for ship hulls, boats and superstructures are specified in **2.3**, Part XVI "Structure and Strength of Fiber-Reinforced Plastic Ships".

6.2.2 Reinforcement material.

6.2.2.1 As reinforcement material, glass-fiber materials in the form of rovings, roving cloths, twisted composite filaments, mats and chemically bonded roving lengths may be used.

6.2.2.2 The application of a reinforcement material other than glass fiber may be permitted on the basis of the test results confirming the possibility of its application.

6.2.2.3 The moisture content in glass-fiber reinforcement material shall not exceed 0,2 % of the mass of the material.

6.2.2.4 Cloths of glass-fiber reinforcement material shall be treated with water-repellent adhesive compound to ensure a secure bond with the resin applied.

6.2.2.5 The adhesive in glass-fiber reinforcement materials, by which the bondage of roving lengths is ensured in mat, shall be well soluble in the resin without any adverse effect on its properties. A rapid solution of the adhesive shall not result in the mat collapsing while being impregnated with the resin.

6.2.2.6 The mechanical properties of reinforcement materials shall be in compliance with the Registerapproved documentation.

6.2.2.7 Each batch of reinforcement material shall be provided with the Manufacturer's Certificate stating the following:

manufacturer;

mark;

type of cloth;

weight per unit length or area;

type of resin, for which the water-repellent adhesive treatment was made;

test results.

6.2.3 Bonding agent.

6.2.3.1 When manufacturing fiber-reinforced plastics, polyester resins approved by the Register shall be used as bonding agent base.

6.2.3.2 Application of polyester resins is recommended.

6.2.3.3 Addition of pigments and other colouring agents adversely affecting the resin properties is permitted for the decorative layer compound only, and their content shall not exceed 15 % of the resin weight.

6.2.3.4 Under the effects of sea water in conformity with **2.3.12.1**, oil products in conformity with

2.3.11.2 and ageing in conformity with **2.3.10.1**, the mechanical properties of resin shall not deteriorate by more than 25 % as compared to their initial values. Tests may be conducted for both the hardened resin itself and as part of a FRP (with reinforcement material).

6.2.3.5 Instructions on the application and storage of the resin shall be submitted to the Register together with the documentation proper, which, among other things, shall specify the chemical resistance of the resin to the exposure to various aggressive media.

6.2.3.6 Each batch of resin shall be provided with the Manufacturer's Certificate stating the following:

manufacturer;

mark;

test results.

6.3 LAMINATED TEXTILES

6.3.1 General.

6.3.1.1 The present requirements apply to textiles subject to survey by the Register, which have a rubber or plastic watertight coating and are intended for structures that are under pressure during their service.

6.3.2 Properties.

6.3.2.1 Laminated textiles shall be air-tight and shall comply with the requirements of Table 6.3.2.1.

Table 6.3.2.1. **Mechanical properties**

Tensile strength, kN/5, cm		**Fracture elongation, %**		**Tear propagation strength, N**		**Coating adhesion, N/cm**
warp	weft	warp	weft	warp	weft	
min		max		min		
1	2	3	4	5	6	7
2,0		35		40		10
Note: The tensile strength may be reduced to equal the strength required by the Register for the envelopes of particular structures, but not more than to four times the hoop stress developed in gas-filled pipes under the pressure, at which safety valves open.						

6.3.2.2 After ageing and bend test, the change of tensile strength in laminated textiles shall not be more than 10 % of that before ageing, and the difference of dimensions along the warp and weft before and after ageing shall not be more than 2 %.

When the adhesive joints of laminated textiles are tensile-tested before and after ageing, the rupture shall occur in the base material.

6.3.2.3 No stickiness, cracks, delaminations or colour modifications shall be observed on the surface of laminated textiles after testing for bending, ageing, creasing and shape stability after ageing, oil resistance, cold resistance, resistance to ozone and sea water.

6.3.2.4 The colouring agents applied shall not detrimentally affect the properties of the base material.

6.3.3 Sampling.

Sampling for test specimens shall be effected from each batch of laminated textiles 0,1 m from the edge and at least 1 m from the roll end. Samples shall be taken 24 h after fabrication at the earliest.

6.3.4 Scope of testing.

6.3.4.1 Laminated textiles are submitted for tests in batches. A batch consists of one roll fabricated during one manufacturing cycle.

If the results of mechanical testing are continuously satisfactory, the mass of material comprising the batch may be increased.

6.3.4.2 For each batch, tensile tests to determine fracture elongation as stated in **2.3.2.2**, test to determine tear propagation strength as stated in **2.3.2.3** on ten specimens each (five along the warp and five along the weft), delamination test as stated in **2.3.2.4** on three specimens and air permeability test as stated in **2.3.13** on two specimens shall be effected, and the material mass shall be determined in accordance with a recognised standard.

6.3.4.3 For the purpose of laminated textiles approval, tensile test after ageing in accordance with **2.3.10.2**, bend test in accordance with **2.3.5.3**, test of the bond joints of laminated textiles before and after ageing in accordance with **2.3.2.5** on ten specimens each (five along the warp and five along the weft), creasing and shape stability test after ageing in accordance with **2.3.10.3**, oil product resistance test in accordance with **2.3.11.2**, sea water resistance test in accordance with **2.3.12.2**, cold resistance test in accordance with **2.3.14** and ozone resistance test in accordance with **2.3.15** shall be effected in addition to those mentioned under

6.3.4.2.

6.3.4.4 The test results shall comply with the requirements of **6.3.2** and shall be given in the Manufacturer's Certificate.

6.3.5 Inspection.

On the surface of laminated textiles, damage, recesses, dead folds, textile flaw marks, spots, blisters, porosity or other defects, which may preclude their application in accordance with the purpose, are not permitted.

6.3.6 Marking.

Marking of laminated textiles is effected in accordance with **1.4**. In addition, the mass of material per unit of area shall be stated.

6.4 FOAM PLASTICS

6.4.1 General.

6.4.1.1 The present requirements apply to foam plastics used for the manufacture of items subject to survey by the Register.

6.4.2 Properties.

6.4.2.1 By their properties and conditions of application, foam plastics are subdivided into three grades:

grade 1 is represented by rigid foam plastics for filling up the spaces between supporting surfaces of sandwich structures;

grade 2 is represented by rigid foam plastics for filling up the air chambers of lifeboats and other similar hollow spaces;

grade 3 is represented by elastic foam plastics for the manufacture of buoyant material for life jackets.

6.4.2.2 Foam plastics shall chiefly have closed-cell structure.

6.4.2.3 The shrinkage of grades 1 and 2 foam plastics shall not result in poor adhesion to boundary surfaces.

6.4.2.4 The physical and mechanical properties of grade 1 foam plastics shall be in accordance with Table 6.4.2.4.

Table 6.4.2.4

Apparent density, min, g/cm^3	0,8
Bending strength, min, MPa	0,3
Modulus of elasticity in bending, min, MPa	12
Compression strength, min, MPa	0,7
Modulus of elasticity in compression, min, MPa	30
Water absorption in 24 h, max, kg/m^2	0,2

6.4.2.5 The physical and mechanical properties of grades 2 and 3 foam plastics shall be in accordance with the Register-approved documentation.

6.4.2.6 Under the effects of sea water and petroleum products, the mechanical properties of grade 1 foam plastics shall not deteriorate by more than 25 % as compared to the initial values.

6.4.2.7 Under the effects of 10 cycles of temperature variation in conformity with **2.3.1**, high-octane petrol in conformity with **2.3.11.3** and fresh water as stated in **2.3.9.2**, the buoyancy of grade 2 foam plastics shall not be reduced by more than 5 % of the initial value.

6.4.2.8 When approving foam plastics of grade 2, they shall also be tested by conditioning in oil products in conformity with **2.3.11.4**.

6.4.2.9 Under the effects of 10 cycles of temperature variation in conformity with **2.3.16** and of fresh water as stated in **2.3.9.2**, the floatability of grade 3 foam plastics shall not be reduced by more than 5 %, and if they come additionally under the effects of diesel oil in conformity with **2.3.11.3**, it shall not be reduced by more than 10 % of the initial value.

6.4.2.10 The cyclic effects of temperature, oil products and fresh water shall not bring about a deterioration of the mechanical properties of grades 2 and 3 foam plastics.

6.4.3 Sampling.

Samples shall be cut out in the middle of a foam-plastic block, and a section with the most uniform cell structure shall be chosen for the purpose.

6.4.4 Scope of testing.

6.4.4.1 Testing of grade 1 foam plastics.

6.4.4.1.1 Compression strength is determined on three specimens in compliance with **2.3.3.2**, and for this purpose the maximum load causing an abrupt failure of the foam plastic structure is determined, which shall be reached within 1 min approximately.

6.4.4.1.2 Apparent density is determined on three specimens in compliance with **2.3.7**.

6.4.4.1.3 Bending strength is determined on three specimens in compliance with **2.3.5.1**.

6.4.4.1.4 Water absorption is determined on five specimens in compliance with **2.3.9**.

6.4.4.1.5 Resistance to oil products is determined in conformity with **2.3.11.2**, and to sea water, in conformity with **2.3.12.1**. Each of the tests is made on three specimens only at the time of the foam plastic approval.

6.4.4.2 Grade 2 and 3 foam plastics are tested in conformity with technical documentation approved by the Register.

6.4.5 Inspection.

During the inspection, the surface structure of the foam plastic shall be checked at cross section for closed cells.

Under the cyclic effects of temperatures, oil products and fresh or sea water, no cracks, bulges or disintegration shall be visible on the foam plastic surface.

6.4.6 Marking. The marking of foam plastics is effected in conformity with **1.4**. The test results shall be entered in the Manufacturer's Certificate.

6.5 PROTECTIVE COATINGS

6.5.1 Anticorrosive protective coatings.

6.5.1.1 Epoxy-based coatings or equivalent shall be applied to the inner surfaces of ballast tanks in accordance with the manufacturer's recommendations. Light colours of the coatings are the most preferable.

For ships covered by SOLAS-74 with regard to IMO resolution MSC.216(82), all dedicated seawater ballast tanks arranged in ships and double-side skin spaces arranged in bulk carriers shall be coated in accordance with the Performance Standard for Protective Coatings (IMO resolution MSC.215(82)) as amended and by the MSC.1/Circ.1378 and MSC.216(82)).

The following tanks shall not be considered to be dedicated seawater ballast tanks and shall therefore be exempted from the application and requirements of IMO resolution MSC.216(82):

- ballast tanks identified as "Spaces included in Net Tonnage" in the 1969 ITC Certificate;
- sea water ballast tanks in passenger ships also designated for the carriage of grey water or black water confirmed by the coating manufacturer to be resistant to the media stored in these tanks and provided such coatings are applied and maintained according to the coating manufacturer's procedures;
- sea water ballast tanks in livestock carriers also designated for the carriage of the livestock dung confirmed by the coating manufacturer to be resistant to the media stored in these tanks and provided such coatings are applied and maintained according to the coating manufacturer's procedures.

6.5.1.2 Protective coatings for cargo tanks of oil tankers specified in **1.2.5.3**, Part II «Hull», shall meet the requirements of IMO resolution IMO MSC.288(87) with MSC.342(91), MSC.1/Circ.1479, MSC.1/Circ.1279, MSC.1/Circ.1399.

6.5.1.3 Protective coatings of internal surfaces of the cargo holds and external surfaces of hatch coamings and hatch covers required by **3.3.5.1**, Part II "Hull" shall be applied in accordance with the recommendations of the manufacturer.

6.5.1.4 It is recommended to protect the inner spaces of cofferdams, duct keels, supports of transverse bulkheads and other similar void spaces of oil tankers and bulk carriers with protective coatings in accordance with IMO resolution MSC.244(83).

6.5.1.5 The procedure for approval of protective coatings of hull structures is given in Section 3, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

6.5.1.6 Inspection of protective coatings of hull structures is carried out in accordance with 2 Part 5 «Technical Supervision of Ships under Construction» of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

6.5.1.7 Requirements for aluminium coatings, as well as coatings used for interior decoration of the spaces, are specified in **2.1.1.7**, Part VI "Fire Protection".

6.5.1.8 For ships with distinguishing mark **WINTERIZATION (DAT)** in the character of class, paint coatings of hull structures, machinery and equipment exposed to prolonged low temperatures shall have the necessary stability at the design temperature of the structure. The documentation of the coating supplier shall be agreed between the shipowner, the shipyard and the coating manufacturer and submitted to the Register.

6.5.2 Antifouling coatings.

6.5.2.1 The present requirements apply to antifouling coatings of ships of 400 gross tonnage and above engaged in international voyages, including fixed and floating platforms, floating facilities for oil production, storage and offloading, and consider the provisions of the International Convention on the Control of Harmful Anti-Fouling Systems on Ships, 2001 (hereinafter - the AFS-Convention) and Regulation (EC) No. 782/2003 of the European Parliament and of the Council of 2003.

6.5.2.2 Organotin compounds acting as biocides shall not be used on ships as anti-fouling coatings.

It is allowed to use minor quantity of organotin compounds acting as chemical accelerator (such as monosubstituted and disubstituted organotin compounds) provided they do not act as biocides. If used as an accelerator the organotin compounds shall not contain more than 2500 mg of tin in 1 kg of dry colour.

6.5.2.3 Antifouling coatings shall be supplied with the Register Type Approval Certificate. If the Register Type Approval Certificate is not available the provisions of **2.15** and **2.16**, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships shall be considered.
Instructions on issuance of Type Approval Certificate are given in **3.1**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

Instructions on the initial survey in accordance with the AFS-Convention are given in 19.15 of the Guidelines on Technical Supervision of Ships under Construction - for ships under construction, and in **10.1** Part IV "Survey of Ships in Compliance with International Conventions, Codes and Resolutions" of the Guidelines on Technical Supervision of Ships in Service - for ships in service.

6.5.3 Ice-resistant coatings.

6.5.3.1 A coating is considered ice-resistant if it provides the protection of the shipʹ s hull shell against the external actions under the ice navigation conditions demonstrating the performance, which meets the requirements in Table 6.5.3.1.

Ice-resistant coatings shall be applied for ships with distinguishing mark **WINTERIZATION(DAT)** in the class notation as well as for ice class **Ice4**, **Ice5**, **Ice6** ships and icebreakers according to **3.10.4.1**, Part II «Hull» and polar class ships according to **3.11** and Baltic classes **IA Super** and **IA** according to **3.12**, Part II «Hull». Coatings shall be divided into groups and classes in accordance with Table 6.5.3.1. For ships with distinguishing mark **WINTERIZATION(DAT)** in the class notation, the coatings shall be divided only into groups depending on the ice class. For ice class ships complying with **3.10** of Part II "Hull" the ice-resistant coatings are additionally divided into Classes I and II.

6.5.3.2 The underwater portion of the hull and its board to a height of at least 1.0 m above the upper limit of the ice belt shall be covered with an ice-resistant coating (except for the use of a two-layer steel for ice belt covering when applying appropriate means of electrochemical corrosion protection). The documentation of the supplier of the coating shall be agreed between the shipowner, the shipyard, and the manufacturer of the coating and shall be submitted to the Register for approval.

Different colors for each layer shall be used, when applying ice-resistant protective coatings of ice class ships and icebreakers in several layers.

Table 6.5.3.1

Nos.	**Characteristic**	**Value**			
		Group 1 for cebreakers of all ice classes		Group 2 for ships of ice, polar classes and with distinguishing marks: **Ice 4**, **Ice 5**, **Ice 6**, **IA Super, IA** in the class notation	
		Class I	Class II	Class I	Class II
1	**2**	**3**		**4**	
1	Durability as per ДСТУ ISO 12944-6 or the applicable ISO standard for a corrosivity category Im2 in compliance with ДСТУ ISO 12944-2 or the applicable ISO standard (refer to **2.5.1**)	High		High	
2	Adhesion by a cross-cut test method as per ДСТУ ISO 2409 or the applicable ISO standard or X-cut test method as per ДСТУ	not more than 3		not more than 3	

	ISO 16276-2 or the applicable ISO standard, after testing for resistance to low temperature exposure (refer to **2.5.2.3**) depending on the thickness and type of ice-resistant coating				
3	Adhesion strength as per ISO 4624 or the applicable ISO standard (refer to **2.5.3.4**)	above 16 MPa	above 10 MPa	above 10 MPa	above 8 MPa
4	Abrasive wear after 1000 cycle tests on the Taber's abrader (wheel CS-17) (refer to **2.5.4**)	not more than 80 mg	not more than 120 mg	not more than 120 mg	not more than 160 mg
5	Impact resistance as per ДСТУ ISO 6272 or the applicable ISO standard (refer to **2.5.5**)	not less than 5 J		not less than 5 J	
6	Cathode disbondment as per ДСТУ ISO 15711 15711 (method A) or the applicable ISO standard (див. **2.5.6**) (refer to 2.5.6) for coatings compatible with cathode protection	ess than 5 mm after three month testing, ess than 8 mm after six month testing		s than 5 mm after three month testing, less than 10 mm after six month testing	
7	Coefficient of sliding friction for ice (refer to **2.5.7**)	not exceeding 0,03	not exceeding 0,08	not exceeding 0,03	not exceeding 0,08

6.5.4 Primers not removed before welding.

6.5.4.1 Shop primers are thin-layer (up to 30 microns) lacquer coatings, preserving the steel surface from corrosion during transportation, storage and assembly of a structure until the final painting is done.

6.5.4.2 The requirements for qualification testing of all kinds of shop primers not removed before welding for their susceptibility to porosity are specified in **2.6**.

6.5.4.3 Welding of structures subject to the Register technical supervision without removing the shop primer is permitted only provided the latter complies with the requirements of **6.5.4.4**, which is confirmed by the Register Certificate or manufacturing testing at the manufacturers' of welded structures (shipyards) under the Register supervision, as well as the requirements of **6.5.4.5**.

6.5.4.4 A primer not removed before welding shall have the following results of qualification testing performed in compliance with the requirements of **2.6**:

the mean total pore area at the fracture of a singlerun fillet joint shall not exceed 150 mm^2.

6.5.4.5 The requirements for testing of shop primers at the manufacturers' of welded structures.

The acceptance of shop primers not removed before welding is performed on the basis of the satisfactory test results complying with the requirements of **6.5.4.4** and stated in the reports signed by the Register surveyor. The test results are valid only for the particular mark of the shop primer subjected to testing and supplied by the particular manufacturer.

6.6 ROPES OF NATURAL AND SYNTHETIC FIBRE

6.6.1 The present requirements apply to ropes, subject to survey by the Register, which are intended for cargo handling gear, life-saving appliances and other ship appliances.

6.6.2 The ropes shall be manufactured and tested in conformity with standards approved by the Register.

The breaking load on a rope is determined by testing the rope as a whole.

6.6.3 The breaking load on a rope F, in kN, may be determined by the following formula:

$$F = c\left(\sum_{1}^{m} F_m\right) n/z, \qquad (6.6.3)$$

where c – yarn efficiency factor for the rope, which shall be adopted on the basis of standards or calculated as the ratio of the breaking load on the rope as a whole to the total breaking load on all the yarns making up the rope, both the values being stipulated by the standards;

m – number of yarns, subjected to tensile testing, which conform to standards;

F_m – the greatest load, during the tensile test of a yarn, in kN, after which the specimen breaks;

n – number of yarns in a rope;

z – number of yarns subjected to tensile testing, which is adopted equal to 0,5n for ropes below 80 mm in diameter, 0,3n for ropes 80 to 115 mm in diameter and 0,1n for ropes over 115 mm in diameter.

6.6.4 A rope of synthetic fibre shall undergo testing to determine fracture elongation when requested by the customer.

The fracture elongation of a rope σ_{CP}, %, is determined by the formula

$$\sigma_{FE} = (l_p - l_0)/l_0 \cdot 100, \qquad (6.6.4)$$

where l_0 – initial length of the rope specimen tested, in cm;

l_p – length of the same rope specimen under the load equal to the breaking load on the rope as a whole, which shall be found in the standard, in cm.

6.6.5 The compliance of the structure diameter and other parameters of the rope to the standard shall be confirmed by visual testing.

On the surface of a finished rope, no brown spots, mould, burned spots or smell of fume or rot shall be detectable.

The colour of the rope shall be uniform along its whole length and shall not differ from that of the yarn or synthetic fibre, of which the rope is manufactured.

6.6.6 The marking of the ropes is effected in conformity with **1.4**.

6.6.7 The test results shall be entered in the Manufacturer's Certificate, the contents of which shall be agreed with the Register.

6.7 RETRO-REFLECTIVE MATERIALS FOR LIFE-SAVING APPLIANCES

6.7.1 General.

6.7.1.1 The present requirements apply to the retro-reflective materials of life-saving appliances subject to survey by the Register.

6.7.1.2 Proceeding from their service conditions, retro-reflective materials are divided into two types:

type 1 includes materials to be fitted on elastic surfaces occasionally exposed to the weather;

type 2 includes materials to be fitted on rigid surfaces continuously exposed to the weather.

6.7.2 Properties.

6.7.2.1 The tensile strength of retro-reflective materials with an adhesive layer shall not be less than 16 N/25 mm, and of those with a warp for mechanical attachment - 330 N/25 mm in the longitudinal direction and 200 N/25 mm in the transverse direction.

6.7.2.2 Proceeding from the entrance angle and observation angle, the values of the retroreflection factor R, in cd $lx^{-1} \cdot m^{-2}$, shall not be less than those to be found in Table 6.7.2.2.

Table 6.7.2.2

Entrance angle, deg.	**Observation angle, deg.**			
	0,1	0,2	0,5	1
5	1809	175	72	14
30	140	135	70	12
45	85	85	48	9,4

6.7.2.3 When the material is under a water film and after ageing, the retro-reflection factor may be lowered by not more than 20 % as compared to Table 6.7.2.2, and after the abrasion test, it may be lowered by not more than 50 %.

6.7.2.4 Exposure to sea water, mildew, salt fog and ultimate temperatures shall not lower the retroreflection factor of the material.

6.7.2.5 For retro-reflective materials with an adhesive layer, the strength of adhesion to different surfaces shall not be less than 16 N/25 mm.

6.7.2.6 Exposure to ultraviolet irradiation, sea water and distilled water shall not lower the adhesion properties of retro-reflective materials with an adhesive layer.

6.7.3 Sampling.

The sample for the preparation of specimens is taken from each batch of retro-reflective materials at least one metre from the roll end. Before the specimens have been prepared, the sample is conditioned in conformity with **2.3.1.1** during 24 h.

6.7.4 Scope of testing.

6.7.4.1 Retro-reflective materials are submitted for testing in batches. A batch comprises one roll manufactured during one production cycle. Where the test results are stable, the bulk of the batch may be increased.

6.7.4.2 Each batch of the material is tensile-tested in conformity with **2.3.2.6**, and the strength of adhesion to different surfaces is determined in conformity with **2.3.2.7** for the material with an adhesive layer, as well as the retro-reflection factor in conformity with **2.3.18.1**.

6.7.4.3 When approving retro-reflective materials, besides the tests metnioned in **6.7.4.2**, the retroreflection factor is determined for the material under a water film in conformity with 2.3.18.2, after ultraviolet irradiation in conformity with **2.3.10.4**, abrasion in conformity with **2.3.22**, sea-water conditioning in conformity with **2.3.12.3**, exposure to salt fog in conformity with **2.3.12.4**, to ultimate temperatures in conformity with **2.3.16** and mildew in conformity with **2.3.21**. Besides, the bend test in conformity with **2.3.19**, adhesion test in conformity with **2.3.20** and contaminant-resistance test in conformity with **2.3.23** are conducted.

For retro-reflective materials with an adhesive layer, the strength of adhesion to different surfaces shall be determined in conformity with **2.3.2.7** after exposure to the ultraviolet irradiation in conformity with **2.3.10.4** and to distilled and sea water in conformity with **2.3.12.5**.

6.7.4.4 Each type of tests shall be conducted at least on three specimens.

6.7.4.5 The test results shall comply with the requirements of **6.7.2**.

6.7.4.6 Under the effects of seawater during 10 min, salt fog and ultimate temperatures during 4 h, and after the bend and adhesion tests, no cracks, delamination, bulging, stickiness or change of colour shall be observed on the surface of retro-reflective materials, and their size shall be the same.

6.7.5 Inspection.

The surface of retro-reflective materials shall be free from injuries, recesses, creases, delaminations, stains or other defects, which might adversely affect their application in accordance with the purpose.

6.7.6 Marking.

The marking of retro-reflective materials shall be effected in conformity with **1.4**.

The test results shall be entered in the Manufacturer's Certificate.

6.8 PLASTIC PIPES AND FITTINGS

6.8.1 General.

Plastic pipes shall comply with the requirements of standards approved by the Register.

6.8.2 Strength.

6.8.2.1 The strength of pipes shall be determined by hydraulic failure testing of specimens.

6.8.2.2 The strength of fittings and joints shall not be less than that of pipes.

6.8.2.3 The nominal pressure p_{nom} shall be determined from the following conditions:

For internal pressure: $p_{nom} < p_{sth} /4$ або $p_{nom} < p_{lth} /2,5$,

where p_{sth} – short-term hydraulic test pipe failure pressure;

p_{lth} – = long-term hydraulic test pipe failure pressure (more than 100 000 h);

For external pressure: $p_{nom} < p_{\text{p}}/3$;

where p_{col} – pipe collapse pressure.

6.8.2.4 In any case the collapse pressure shall not be less than 0,3 MPa.

6.8.2.5 The maximum working external pressure is a sum of internal vacuum and external pressure of the pipe tested.

6.8.2.6 The maximum permissible working pressure shall be determined taking into account the maximum possible working temperatures in accordance with the manufacturer's recommendations.

6.8.3 Axial strength.

The sum of longitudinal stresses because of pressure, weight and other loads shall not exceed the allowable stress in the longitudinal direction.

For fibre reinforced plastic pipes the sum of longitudinal stresses shall not exceed the half of nominal circumferential stresses determined under nominal pressure.

6.8.4 Impact resistance.

Plastic pipes shall have an impact resistance sufficient for preserving the integrity of piping under external effects likely to occur in service, such as tods falling on them, for instance.

6.8.5 Temperature.

6.8.5.1 The permissible working temperature depending on the working pressure shall be determined in accordance with the manufacturer's recommendations, but in any case, it shall be at least 20°C lower than the minimum heat distortion/deflection temperature of the pipe material.

6.8.6 Fire protecting coatings.

Where fire protecting coatings of pipes and fittings are used for achieving the required fire resistance level, they shall comply with the requirements of **6.8.6.1 − 6.8.6.4**.

6.8.6.1 As a rule pipes shall be delivered from the manufacturer with fire protecting coatings on.

6.8.6.2 Fire protecting properties of coatings shall not be diminished when exposed to sea water or oil products. It shall be demonstrated that the coating is resistant to products likely to come into contact.

6.8.6.3 In considering fire protecting coatings such characteristics as thermal expansion, resistance against vibrations and elasticity shall be taken into account.

6.8.6.4 Fire protecting coatings shall have sufficient resistance to impact to retain their integrity.

6.8.7 Materials approval and quality control during manufacture.

6.8.7.1 Plastic pipes and fittings shall be manufactured by the works having the quality system approved by the Register.

6.8.7.2 Specimens of pipes and fittigs of each type and size shall be tested for compliance with the requirements of the Rules.

6.8.7.3 Serial specimens of pipes and fittings for tests determining strength, fire resistance and low surface flame spread characteristics, electrical resistance (for electrically conductive pipes) shall be chosen in accordance with the procedure approved by the Register.

6.8.7.4 Each pipe and fitting shall be tested by the manufacturer at a hydrostatic pressure not less than 1,5 times the nominal pressure.

Alternatively, for pipes and fittings not employing hand lay up techniques, the hydrostatic pressure test may be carried out in accordance with the hydrostatic testing requirements stipulated in the recognized national or international standard to which the pipe or fittings are manufactured, provided that there is an effective quality system in place.

6.8.7.5 Pipes and fittings shall be permanently marked with identification in compliance with the approved standard. Identification shall include the nominal pressure, the design standard, in accordance with which the pipe is manufactured, and the pipe material.

6.8.7.6 In case the manufacturer does not have the quality system approved by the Register, each batch of pipes and fittings shall be tested for compliance with the requirements of the Rules under the technical supervision of the surveyor to the Register.

6.9 POLYMER COMPOSITE MATERIAL FOR THE GANGWAYS OF OIL TANKERS

6.9.1 The requirements of this Chapter apply to the polymer composite material (fiber-reinforced plastic) of the gangways of oil tankers as specified in 8.6.9, Part III "Equipment, Arrangements and Outfit".

6.9.2 Material shall comply with the following requirements:

6.1 of this Part;

possessing the characteristics of low flame spread, non-excessive smoke and toxic products generation at elevated temperatures in accordance with **1.6**, Part VI "Fire Protection";

possessing the constructive integrity as a result of fire exposure defined by the standards recognized by the Register (ASTM F3059-14 standard may be applied).

7. ANCHOR AND MOORING CHAIN CABLES

7.1 ANCHOR CHAIN CABLES AND ACCESSORIES

7.1.1 General.

7.1.1.1 The present requirements apply to the materials, design, manufacturing and testing of anchor chain cables and accessories used for ships. The requirements for the chafing chain for emergency towing arrangements are given in **7.1.6**.

Unstudded chain cables may be manufactured according to the national or international standards recognized by the Register.

7.1.1.2 Chain cables and accessories shall be made and tested by the manufacturers recognized in accordance with **1.3.1.2**. In addition to the mentioned in **1.3.1.2**, the request shall indicate the material grade, nominal dimensions and, if necessary, specification for the material. If there are several chain cable grades in the request, tests may be conducted only for the highest grade, provided the chain cable material, manufacturing methods and heat treatment are unchanged.

7.1.1.3 Depending on the tensile strength of the chain cable steel used for manufacture, stud link chain cables and accessories are subdivided into grades 1, 2 and 3.

7.1.2 Materials for chain cables and accessories.

7.1.2.1 All the materials used for the manufacture of chain cables shall be made by the manufacturers recognized in accordance with **1.3.1.2**.

7.1.2.2 Unless otherwise stated, the rolled products, forgings and castings for chain cables and accessories shall meet the requirements of **3.6**.

The Grade 1 rolled products may be used for the manufacture of chain cables with the Manufacturer's Certificates.

7.1.2.3 The studs shall be made of steel corresponding to that of the chain cable links or from rolled, forged or cast carbon steels. The use of other materials, e.g. grey or nodular cast iron is not permitted.

7.1.3 Design and manufacture.

7.1.3.1 Chain cable links are manufactured by flash butt welding using bar material. Manufacture of the links by drop forging or steel casting is permitted. Studless links of 26 mm diameter and below may be manufactured by pressure butt welding.

7.1.3.2 Accessories such as kenter and joining shackles, swivels and swivel shackles shall be forged or cast in steel of at least Grade 2. These parts may also be welded.

7.1.3.3 The design of chain cable links and accessories shall comply with specifications approved by the Register bearing in mind Figs. 7.1.3-1 to 7.1.3-7 (dimensions on all figures are given multiple to the nominal diameter of the usual link), and length of chain cable shall comprise an odd number of links**.**

Where designs do not comply with this and where accessories are welded, relevant drawings shall be submitted to the Register, and the specification shall include full details of the manufacturing process and the heat treatment.

7.1.3.4 According to the grade of steel, chain cables and accessories shall be supplied in one of the conditions specified in Table 7.1.3.4.

Table 7.1.3.4. **The heat treatment of finished chain cables and accessories**

Steel grade	Condition of supply	
	Chain cable	Accessories
1	As welded or normalized	Not regulated
2[1]	As welded or normalized	Normalized
3	Normalized, normalized and tempered or quenched and tempered	
[1] Chain cables made by forging and casting shall be supplied in the normalized condition.		

The heat treatment shall be performed prior to mechanical tests and also prior to the breaking load and proof load testing.

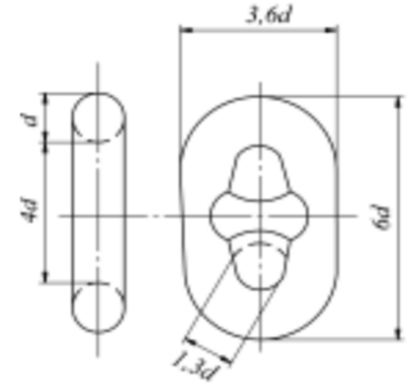


Fig. 7.1.3-1. Common link

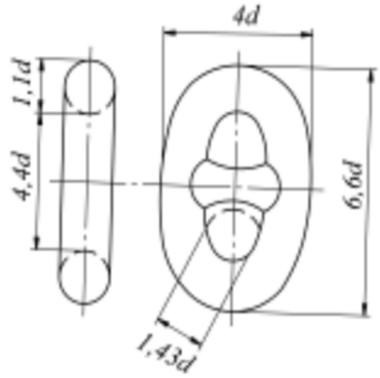


Fig. 7.1.3-2. Enlarged link

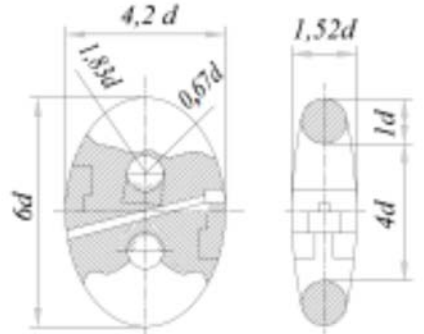


Fig. 7.1.3-4. Kenter joining link

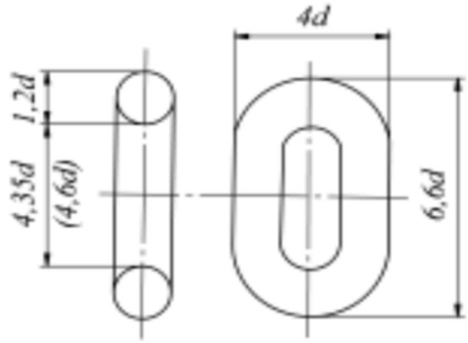


Fig. 7.1.3-3. Studless link

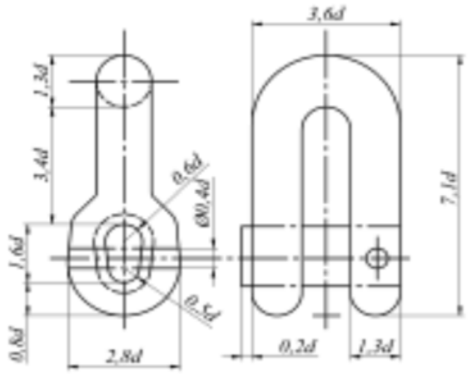


Fig. 7.1.3-5. Joining shackle

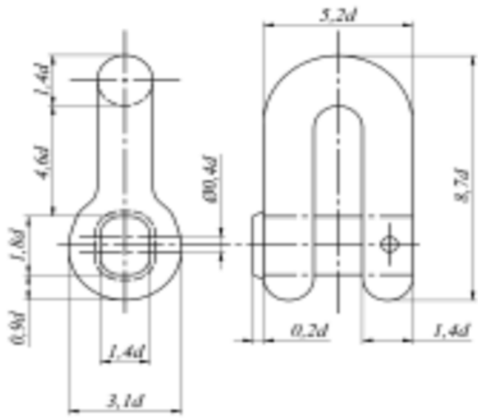


Fig. 7.1.3-6. End shackle

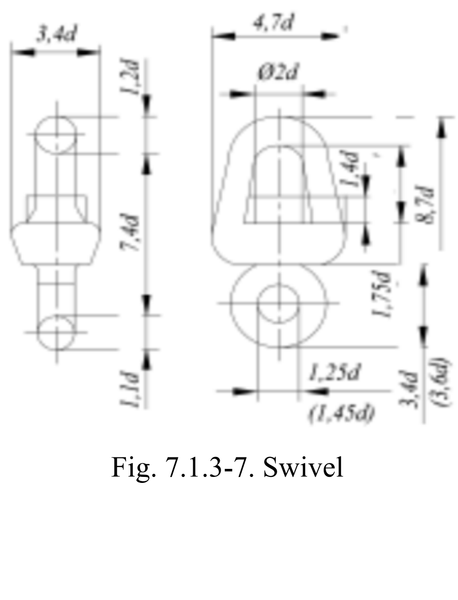


Fig. 7.1.3-7. Swivel

7.1.3.5 The mechanical properties of the material of a finished chain cable and accessories shall be in accordance with Table 7.1.4.3.3.

7.1.3.6 Chain cables and accessories shall be manufactured in a manner such as to withstand the proof and breaking loads indicated in Table 7.1.4.1.2 depending on the relevant chain cable grade.

7.1.3.7 All chain links and accessories shall have a clean surface consistent with the method of manufacture and be free from cracks, notches, inclusions and other defects impairing the performance of the product. The flashes produced by upsetting or drop forging shall be properly removed. Minor surface defects may be fround off so as to leave a gentle transition to the surrounding surface.

Remote from the crown local grinding up to 5 % of the nominal link diameter or item thickness may be permitted.

7.1.3.8 The dimensions of stud chain links and accessories shall comply with Figs. 7.1.3-1 to 7.1.3-7 and with approved specifications. The dimensions of studless links shall comply with the requirements of the recognized standards and specifications approved by the Register.

7.1.3.9 Allowable tolerances of chain link dimensions.

7.1.3.9.1 Diameter tolerances in the elbow outside the link contact area shall comply with the requirements of Table 7.1.3.9.1.

Table 7.1.3.9.1. **Allowable tolerances of chain link diameter**

Nominal link diameter, mm	Allowable tolerances[1], mm
Up to 40	–1
Over 40 up to 84	–2
Over 84 up to 122	–3
Over 122	–4

[1]The plus tolerances shall not exceed 5 % of the nominal diameter.

7.1.3.9.2 The cross-sectional area of the elbow shall have no negative tolerance. For the purpose of determining the cross-sectional area the diameter adopted is an arithmetic mean of four values measured at points uniformly distributed along the cross section perimeter.

7.1.3.9.3 Allowable tolerance on assembly measured over a length of 5 links shall not exceed +2,5 % of the nominal length.

The length of the chain cable shall be measured after applying a proof load and, preferably, at the loading of 10 % of the minimal value of the proof load.

7.1.3.9.4 Studs shall be located in the link centrally and perpendicular to longitudinal axis of the link, although the studs of the final link at each end of any length may also be located off-centre to facilitate the insertion of the kenter and joining shackles.

The following tolerances are permitted provided, that the stud fits snugly and its ends lie practically flush against the inside of the link:

maximum off-centre distance *X*: 10 % of the nominal diameter *d*;

maximum deviation α from the 90° - position: 4°.

The tolerances shall be measured in accordance with Fig. 7.1.3.9.4.

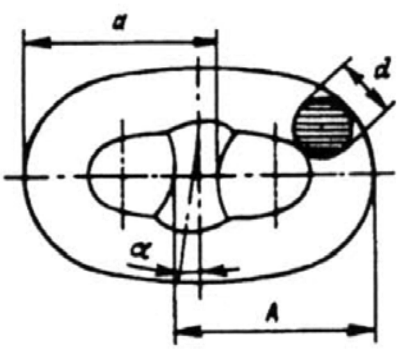


Fig. 7.1.3.9.4; X = (A – a)/2

7.1.3.10 The following tolerances are applicable in accessories:

nominal diameter +5-0 %;

other diameter ±2,5 %.

7.1.3.11 The welding of studs shall be in accordance with procedure approved by the Register subject to the following conditions:

The studs shall be of weldable steel in accordance with **7.1.2.3**.

The studs shall be welded at one end only, i.e. opposite to the weldment of the link.

The stud ends shall fit the inside of the link without appreciable gap.

The welds, preferably in the downhand position, shall be executed by qualified welders using suitable welding consumables.

All welds shall be carried out before the final heat treatment of the chain cable.

The welds shall be free from defects liable to impair the proper use of the chain cable.

Undercuts, end craters and similar defects shall, where necessary, be ground off.

A procedure for the welding of chain studs shall be effected.

7.1.4 Testing of finished chain cables.

7.1.4.1 Proof and breaking load testing.

7.1.4.1.1 All finished chain cables shall be subjected to the tests specified below in the presence of a surveyor to the Register.

To ensure the proper visual testing of the chain cable and of its weld in particular, if present, the chain cables shall be submitted for tests free from paint and anti-corrosion media.

The tests shall be conducted on the equipment approved by the relevant competent organizations in the laboratory recognized by the Register and be witnessed by the Register representative.

7.1.4.1.2 Each chain cable length (27,5 m) shall be subjected to the proof load testing in accordance with the requirements of Table 7.1.4.1.2.

Table 7.1.4.1.2

Test Steel grade	**Steel grade**		
	1	**2**	**3**
Proof load, kN	$0,00686d^2(44 - 0,08d)$	$0,00981d^2(44 - 0,08d)$	$0,01373d^2(44 - 0,08d)$
Breaking load, kN	$0,00981d^2(44 - 0,08d)$	$0,01373d^2(44 - 0,08d)$	$0,01961d^2(44 - 0,08d)$
Note: d— nominal diameter, mm.			

7.1.4.1.3 For the breaking load test, one sample comprising at least of three links shall be taken from every four length of the chain cable. The links concerned shall be made in a single manufacturing cycle together with the chain cable and be welded and heat-treated together with it. The breaking load according to Table 7.1.4.1.2 shall be maintained for a minimum of 30 s.

7.1.4.1.4 If the tensile loading capacity of the testing machine is insufficient to apply one breaking load for chain cables of large diameter, another equivalent testing method shall be agreed with the Register.

7.1.4.2 Retests.

7.1.4.2.1 Shall a breaking load test fail, a further test specimen may be taken from the same length of chain cable and tested. The test shall be considered successful if the requirements are then satisfied. If the retest fails, the length of chain cable concerned shall be rejected. If the manufacturer so wishes, the remaining three lengths belonging to the unit test quantity may then be individually subjected to test at the breaking load. If one such test fails to meet the requirements, the entire unit test quantity is rejected**.**

7.1.4.2.2 Shall a proof load testing fail, the defective link (links) shall be replaced, a local heat treatment to be carried out on the new link (links) and the proof load testing shall be repeated. An investigation shall be made to identify the cause of the failure.

7.1.4.3 Tensile and impact testing of specimens cut out of a finished chain cable.

7.1.4.3.1 For Grade 2 and 3 chain cables, mechanical test specimens shall be taken from every four lengths according to the requirements of Table 7.1.4.3.1.

For forged and cast chain cables, the tests shall be carried out on the metal of each heat and charge (heat treatment).

Sampling is effected according to **3.6.5** and retesting — according to **3.6.5.4**. Tensile test transverse to the weld and an impact test with a notch along the weld for specimens taken from the weldment may be carried out.

Testing and retesting are conducted in the presence of the Register representative.

7.1.4.3.2 For the purpose of test specimen preparation, provision shall be made for an additional link (or where the chain diameter is small, several links) in a length of chain cable. The additional link shall be manufactured by the same procedure as the specimen for breaking test in accordance with **7.1.4.1.3**.

7.1.4.3.3 The test results shall comply with the requirements of Table 7.1.4.3.3 and shall be indicated in the certificate.

Table 7.1.4.3.1 **Number of mechanical test specimens for finished chain cables and accessories**

Steel grade	Manufacturing method	Condition of supply	Number of test specimens		
			Tensile test for base metal	Charpy V-notch impact test, KV	
				Base metal	Weldment
1	Flush-butt welded	AW, N	Not required	Not required	Not required
2	Flush-butt welded	AW	1	3	3
		N	Not required	Not required	Not required
	Forged or cast	N	1	3 (Not required for chain cables)	3
3	Flush-butt welded	N, NT, QT	1	3	3
	Forged or cast	N, NT, QT	1	3	Not regulated
Symbols: AW = as welded; N = normalized; NT = normalized and tempered; QT = quenched and tempered.					

Table 7.1.4.3.3. **Mechanical properties of finished chain cables and accessories**

Категорія сталі	Yield stress, R_{EH} min, N/mm²,	Tensile strength, R_m, N/mm²	Elongation A5, min, %	Reduction in area Z, min, %	Charpy V-notch impact test[1], *KV*		
					Температура, °C	Impact energy value, min, J	
						Base metal	Weldment
1	Not required						
2	295	490 - 690	22	Not required я	0	27	27
3	410	690min	17	40	0	60	50
					- 20	35	27
[1] The impact tests for Grade 3 are carried out at a temperature of -20° C.							

7.1.4.4 Chain cables shall be marked at both ends of each length, and the marking shall include certificate number, chain cable grade and the Register stamp.

The arrangement of symbols comprising the marking shall be in accordance with Fig. 7.1.4.4.

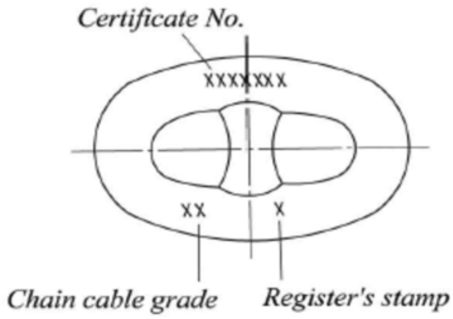


Fig. 7.1.4.4

7.1.5 Testing of accessories.

7.1.5.1 Proof and breaking load testing.

7.1.5.1.1 All chain cable accessories are subject to the tests below witnessed by the Register representative. To ensure the proper visual testing, of welded joints in particular, if present, the accessories shall be submitted for tests free from paint and anti-corrosion media.

7.1.5.1.2 All accessories are proof load tested in accordance with the above requirements and those in Table 7.1.4.1.2.

7.1.5.1.3 For breaking load test in accordance with Table 7.1.4.1.2, the accessories shall be submitted in batches.

A batch of shackles, swivels, swivel shackles, large links and end links shall comprise not more than 25 items and one consisting of Kenter shackles shall comprise 50 items of the same grade and size, which were manufactured from material of the same heat and heat treated in the same furnace charge.

Out of each batch, one item is subjected to the breaking load test and after testing, the use of the items according to the purpose is not permitted.

7.1.5.1.4 Breaking load test may be waived if:

the breaking load is confirmed by the positive results of the initial testing of the item when the manufacturer is approved by the Register; and

the results of mechanical testing in accordance with **7.1.5.2** are satisfactory for each batch; and

the parts are subjected to non-destructive testing in accordance with the procedure approved by the Register.

7.1.5.1.5 Notwithstanding the above, the items, which withstood the tests with a breaking load prescribed for the particular chain cable, may be used for the intended purpose, provided the following conditions were met in manufacturing of the items:

.1 the material, of which the items are made, meets more severe requirements than those prescribed for the chain cable, with which the items are expected to be used (e.g., material corresponds to Grade 3 where the required grade is 2);

.2 the material, of which the items are made, corresponds to the grade required for the item but the item has greater dimensions than those required and has withstood the tests with breaking load at least 1,4 times over the prescribed one.

7.1.5.2 Mechanical tests.

7.1.5.2.1 Unless otherwise stated, forgings and castings after heat treatment shall meet the requirements of Table 7.1.4.3.3. For sampling, castings and forgings of similar dimensions originating from the same heat treatment charge and the same heat of steel may be combined into batches. Testing and retesting shall be witnessed by the Register representative. From each manufacturing batch in one material grade, one tensile test specimen and the set of three-impact test specimens are taken in accordance with Table 7.1.4.3.1.

Specimens are machined in accordance with **3.6.5**; the retests are performed according to **3.6.5.4**. Enlarged links and end links need not be tested, provided they are manufactured and heat treated together with the chain cable.

7.1.5.2.2 The results of the mechanical tests shall comply with the requirements of Table 7.1.4.3.3 і повинні бути зазначені в сертифікаті.

7.1.5.3 Each item of accessories shall be marked, and the marking shall include the certificate number, grade and the Register stamp.

7.I.6 Chafing chain for emergency towing arrangements.

7.1.6.1 General.

The present requirements apply to the chafing chain for chafing gear of emergency towing arrangements (ETA) with specified safe working load of 1000 kN (ETA1000) and 2000 kN (ETA2000).

7.1.6.2 Chafing chains shall be manufactured only by the works recognized by the Register according to **7.1.1.2**.

7.1.6.3 The materials used for the manufacture of the chafing chain shall meet the requirements of **7.1.2**.

7.1.6.4 The chafing chain shall be designed, manufactured and tested in accordance with the requirements of **7.1.3 — 7.1.5**.

7.1.6.5 One end of the chafing chain shall be suitable for connection to the strongpoint of a towed vessel, and the other end of the chafing chain shall be fitted with a pear-shaped open link allowing connection to a shackle (refer to Fig. 7.1.6.5).

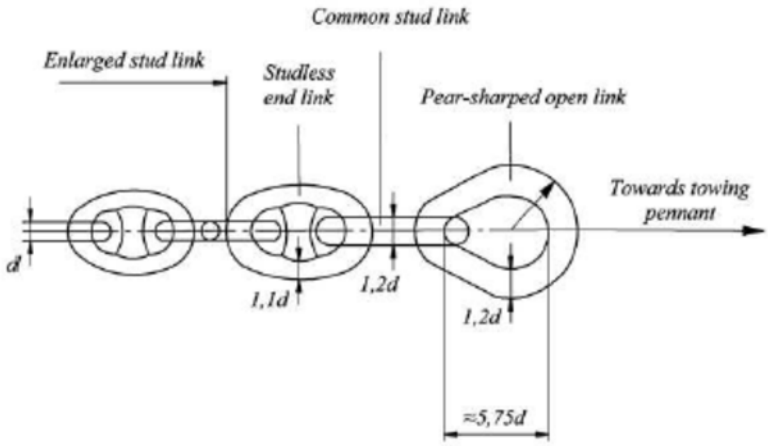


Fig. 7.1.6.5

7.1.6.6 The chafing chain for emergency towing arrangements shall be of Grade 2 or 3 and withstand a breaking load of at least twice the safe working load.

For each type of ETA, the nominal diameter of a common link shall be in accordance with Table 7.1.6.6.

Table 7.1.6.6

Type of ETA	**Nominal diameter of common link *d*, min, mm**	
	Grade 2	Grade 3
ETA 1000	62	52
ETA 2000	90	76

7.1.7 Documents.

Chains complying with the above requirements shall have the Register certificates containing as a minimum the following data:

certificate number;
order number;
manufacturer's name;
grade;
chemical composition (including the total content of aluminium);
nominal diameter/weight;
proof/breaking load;
type of heat treatment;
manufacturing method;
chain marking;
length;
mechanical properties if needed.

If required, protocols of tests performed may be attached to the certificate.

7.2 MOORING CHAIN AND ACCESSORIES

7.2.1 General.

7.2.1.1 Scope of application.

The present requirements apply to the materials, design, manufacture and testing of mooring chain and accessories intended to be used for mobile offshore units and fixed offshore platforms.

This Chapter also includes requirements for chafing chain for single point moorings, FPSO and similar uses.

The accessories covered are common stud and studless links, connecting common links (splice links), enlarged links, end links, detachable connecting links (shackles), end shackles, subsea connectors, swivels and swivel shackles.

Studless link chain is normally deployed only once, being intended for long-term permanent mooring systems with pre-determined design life.

7.2.1.2 Chain grades.

epending on the nominal tensile strength of the steels used for manufacture, chains and accessories shall be subdivided into five grades, i.e.: R3, R3S, R4, R4S and R5.

Manufacturers propriety specifications approved by the Register for R4S and R5 may vary the design conditions of a chain.

Each grade shall be individually approved. If it is demonstrated that the higher and lower grades are produced to the same manufacturing procedure using the same chemical composition and heat treatment, consideration will be given to qualification of a lower grade by a higher. The parameters applied during qualification shall not be modified during production under the Register technical supervision.

7.2.1.3 Recognition of chain manufacturers.

7.2.1.3.1 Mooring chains and accessories shall be manufactured only by works recognized in accordance with **1.3.1.2**.

For this purpose tests shall be carried out, the scope of which shall include proof and breaking load tests, measurements and mechanical tests including fracture mechanics tests.

7.2.1.3.2 Manufacturers shall submit the information on the works and manufacturing processes in compliance with the requirements in Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships, as well as the following documentation:

bar heating and bending including method, temperatures, temperature control and recording;

flash welding including current, force, time and dimensional variables as well as control and recording of parameters, maintenance procedure and programme for welding machine;

flash removal including method and inspection;

stud insertion method, for stud link chain;

heat treatment including furnace types, means of specifying, controlling and recording of temperature and chain speed and allowable limits, quenching bath and agitation, cooling method after exit;

proof and break loading including method/machine, means of horizontal support (if applicable), method of measurement and recording;

non-destructive testing methods;

the manufacturer's surface quality requirement of mooring chain accessories;

the procedure for removing and replacing defective links without heat treatment of the entire chain.

7.2.1.3.3 For initial approval CTOD tests shall be carried out on the particular mooring chain material.

CTOD tests shall be performed in accordance with a recognized standard such as BS 7448, Part 1 and BS EN ISO 15653:2010.

The CTOD specimen shall be a standard 261 single edge notched bend specimen, test location as shown in Fig. 7.2.1.3.3. The notch of the CTOD specimen shall be located as close to the surface as practicable. The minimum cross section of the test specimen shall be 50x25 mm for chain diameters less than 120 mm, and 80x40 mm for diameters 120 mm and above. CTOD specimens shall be taken from both the side of the link containing the weld and from the opposite side. Three links shall be selected for testing. The tests shall be taken at -20°C and the lowest CTOD of each set of 3 specimens shall meet the minimum values indicated in Table 7.2.1.3.3.

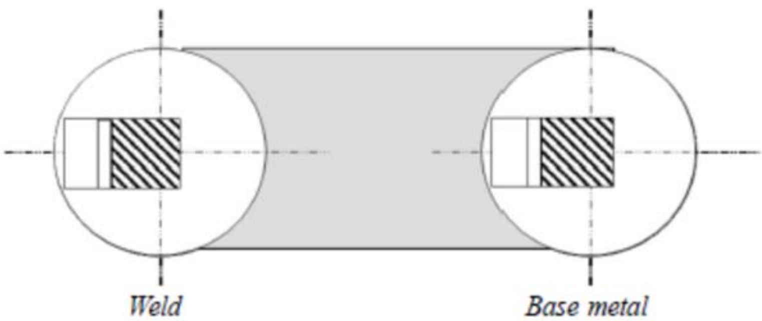


Fig. 7.2.1.3.3. Test location

Table 7.2.1.3.3

Chain grade	R3, mm		R3S, mm		R4, mm		R4S and R5, mm	
	Base metal	Weld metal	Base metal	Weld metal	Base metal	Weld metal	Base metal	Weld metal
Stud links	0,20	0,10	0,22	0,11	0,24	0,12	0,26	0,13
Studless links	0,20	0,14	0,22	0,15	0,24	0,16	0,26	0,17

7.2.1.3.4 Calibration of furnaces shall be verified by measurement and recording of a calibration specimen with dimensions equivalent to the maximum size of link manufactured. The manufacturer shall submit a procedure for furnace temperature surveys, which shall include the following requirements:

the temperature uniformity of furnaces shall be surveyed whenever approval of manufacturer is requested and at least annually during normal operating conditions;

furnaces shall be checked by conveying a monitoring link instrumented with two thermocouples through the furnaces at representative travel speed;

one thermocouple shall be attached to the surface of the straight part and one thermocouple shall be imbedded in a drilled hole located at the mid thickness position of the straight part of the calibration block;

the time-temperature curves shall show that the temperatures throughout the cross section and the soaking times are within specified limits as given in the heat treatment procedure.

7.2.1.3.5 For R4S and R5 chain and accessories, prior to approval, the manufacturer shall undertake experimental tests or have relevant supporting data to develop the chain and accessory material. The tests and data may include: fatigue tests, hot ductility tests (no internal flaws shall develop whilst bending in the link forming temperature range), welding parameter research, heat treatment study, strain age resistance, temper embrittlement study, stress corrosion cracking data and hydrogen embrittlement study, using slow strain specimens in hydrated environments. Reports indicating the results of experimental tests shall be submitted.

7.2.1.4 Approval of quality system at chain and accessory manufacturers.

Chain and accessory manufacturers shall have a documented and effective quality system approved by the Register. The provision of such system is required in addition to, and not in lieu of, the witnessing of tests by a surveyor as specified in **7.2.2 − 7.2.5**.

7.2.1.5 Recognition of bar manufacturers. Rolled bar for chains.

7.2.1.5.1 Bar materials intended for chain and accessories shall be manufactured only by works approved by the Register and holding a Recognition Certificate for Manufacturer (refer to **1.3.1.2** and **3.6**). The recognition is limited to a nominated supplier of bar material. If a chain manufacturer wishes to use material from a number of suppliers, separate recognition tests shall be carried out for each supplier.

7.2.1.5.2 The Recognition Certificate for Manufacturer may be issued to a rolled products supplier only after successful testing of the completed chain. Each grade shall be individually approved. If it is demonstrated that the higher and lower grades are produced to the same manufacturing procedure using the same chemical composition and heat treatment, consideration will be given to qualification of a lower grade by a higher. The parameters applied during qualification shall not be modified during production under the Register technical supervision.

The Recognition Certificate for Manufacturer will normally be limited up to the maximum diameter equal to that of the chain diameter tested.

The rolling reduction ratio shall be recorded in the Recognition Certificate for Manufacturer and shall be at least 5:1 for R3, R3S, R4, R4S and R5. The rolling reduction ratio used in production can be higher, but shall not be lower than that qualified.

7.2.1.5.3 The steelmaker shall submit a specification of the chemical composition of the bar material, which shall be approved by the Register and by the chain manufacturer.

The specification shall be confirmed by the ladle analysis. For grade R4, R4S and R5 chain the steel shall contain a minimum of 0,20 % molybdenum.

7.2.1.5.4 A heat treatment sensitivity study simulating chain production conditions shall be applied in order to verify mechanical properties and establish limits for temperature and time combinations. All test details and results shall be submitted to the Register.

7.2.1.5.5 The bar manufacturer shall provide evidence that the manufacturing process produces material that is resistant to strain ageing, temper embrittlement and for R4, R4S and R5, hydrogen embrittlement. All test details and results shall be submitted to the Register.

7.2.1.6 Recognition of forgings and castings manufacturers. Accessories.

7.2.1.6.1 Forgings and castings manufacturers intended to supply finished or semi-finished accessories shall be recognized by the Register and shall hold the Recognition Certificate for Manufacturer (refer to **1.3.1.2** and **3.6**).

A description of manufacturing processes and process controls shall be submitted to the Register. The scope of recognition is determined by the manufacturer on agreement with the Register. The Recognition shall be limited to a nominated supplier of forged or cast material.

If an accessory manufacturer wishes to use material from a number of suppliers, a separate recognition shall be carried out for each supplier.

7.2.1.6.2 The Recognition Certificate for Manufacturer may be issued to a supplier of forgings and castings only after the successful testing of the completed accessory. Approval for a higher grade does not constitute approval of a lower grade. If it is demonstrated that the higher and lower grades are produced to the same manufacturing procedure using the same steel specification, supplier and heat treatment, lower grade may be approved by a higher.

The Recognition Certificate for Manufacturer shall normally be limited to the type of accessory and the designated mooring grade of material up to the maximum diameter or thickness equal to that of the completed accessory used for testing unless otherwise agreed by the Register. However for the different accessories that have the same geometry, the tests for initial approval shall be carried out on the one having the lowest reduction ratio.

Types of accessories, categories of materials as well as the maximum diameters of accessory pins to maximum diameters shall also be specified in the Recognition Certificate for Manufacturer.

7.2.1.6.3 Forgings. Forgings shall have wrought microstructure and the minimum reduction ratio shall be 3 to 1.

The forging reduction ratio, used in the qualification tests, from cast ingot/slab to forged component shall be recorded. The forging reduction ratio used in production can be higher, but shall not be lower than that qualified.

The degree of upsetting during qualification shall be recorded and maintained during production. Heat cycling during forging and reheating shall be monitored by the manufacturer and recorded in the forging documentation. The manufacturer shall have a maintenance procedure and schedule for dies and tooling which shall be submitted to the Register.

7.2.1.6.4 Forgings and castings manufacturers shall submit a specification of the chemical composition of the forged or cast material, which shall be approved by the Register.

For Grade R4, R4S and R5 chain the steel shall contain a minimum of 0,20 % molybdenum.

7.2.1.6.5 Forgings and castings manufacturers shall provide evidence that the manufacturing process produces material that is resistant to strain ageing, temper embrittlement and for R4S and R5 grades, hydrogen embrittlement.

A heat treatment sensitivity study simulating accessory production conditions shall be applied in order to verify mechanical properties and establish limits for temperature and time combinations (cooling after tempering shall be appropriate to avoid temper embrittlement).

All test details and results shall be submitted to the Register.

7.2.1.6.6 For initial approval CTOD tests shall be carried out. At least three CTOD tests shall be carried out in accordance with a recognized standard such as BS 7448, Part 1 & BS EN ISO 15653:2010. For rectangular accessories, the CTOD test piece shall be a standard 261 single edge notched bend specimen of thickness equal to full thickness of material to be tested. For circular geometries, the minimum cross section of the test specimen shall be 50x25 mm for accessory diameters less than 120 mm, and 80x40 mm for diameters 120 mm and above. The notch of the CTOD specimen shall be located as close to the surface as practicable. CTOD specimens shall be taken from both the side of the link containing the weld and from the opposite side.

Three links shall be selected for testing, a total of six CTOD specimens. The tests shall be taken at -20°C and the results submitted for review. The minimum value of each set of three specimens shall at least meet the requirements as indicated in Table 7.2.1.3.3 for the base metal.

The geometry of accessories can vary. Fig. 7.2.1.6.6 shows the CTOD location for circular and rectangular cross sections such as those of the D-shackle and accessories fabricated from rectangular sections. The orientation of the specimen shall consider the direction of the grain flow. Fig. 7.2.1.6.6, *b* shows two possible sampling positions for CTOD test specimens with notch orientation for rectangular type accessories. The grain flow is considered in the longitudinal direction X.

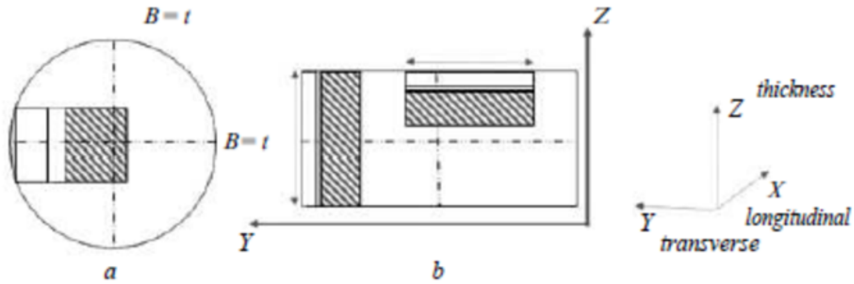


Fig. 7.2.1.6.6 Location of CTOD test specimens: *a* - circular type accessory; *b* - rectangular type accessory

7.2.1.6.7 Calibration of furnaces shall be verified by measurement and recording of a calibration specimen with dimensions equivalent to the maximum size of link manufactured.

Thermocouples shall be placed both on the surface and in a drilled hole located to the mid thickness position of the calibration block.

The furnace dimensions shall be such as to allow the whole furnace charge to be uniformly heated to the necessary temperature. Temperature uniformity surveys of heat treatment furnaces for forged and cast components shall be carried out according to API Spec 6A/ISO 10423, Annex M or ASTM A991. The initial survey shall be carried out with maximum load in the furnace. Subsequent surveys shall be carried out annually and may be carried out with no furnace charge.

The quench bath maximum temperature and the maximum heat treatment transfer times from furnace to quench shall be established and documented. During production the established quenching parameters shall be followed and records shall be maintained of bath temperatures and transfer times.

7.2.1.6.8 The requirements of **7.2.1.3.5** are applicable to Grades R4S and R5.

7.2.1.7 Approval of quality system at accessory manufacturers.

7.2.1.7.1 In accordance with the requirements of **7.2.1.4**.

7.2.2 Materials.

7.2.2.1 Scope of application.

7.2.2.1.1 These requirements apply to rolled steels, forgings and castings used for the manufacture of mooring chain and accessories for mobile offshore drilling units and fixed offshore platforms.

7.2.2.2 The steels shall be manufactured by basic oxygen, electric furnace or such other process approved by the Register. All steels shall be killed and fine grain treated. The austenitic grain size for R3, R3S and R4 Grades shall be 6 or finer (refer to ASTM E112 or equivalent grain size index in accordance with ДСТУ ISO 643 or the applicable ISO standard). Measurements for circular sections shall be taken at 1/3 radius.

7.2.2.2.1.2 Steel for bars intended for R4S and R5 grade chain shall be vacuum degassed. The austenitic grain size shall be 6 or finer (refer to ASTM E112 or equivalent grain size index in accordance with ДСТУ ISO 643 or the applicable ISO standard). Виміри на круглому перерізі повинні виконуватися від третини радіусу.

7.2.2.2.1.3 For R4S and R5 chain the following information shall be supplied by the bar manufacturer to the mooring chain manufacturer and the results included in the chain documentation:

a) each heat shall be examined for non-metallic inclusions. The level of micro inclusions shall be quantified and assessed in accordance with the national and international standards; inclusion levels shall be confirmed as acceptable for the final product.

b) a sample from each heat shall be macro etched according to ASTM E381 or national equivalent, to be sure there is no injurious segregation or porosity.

c) jominy hardenability data, according to ASTM A255 or national equivalent, shall be supplied with each heat.

The results of the above tests are to be included in the chain documentation.

7.2.2.2.2 Chemical composition.

7.2.2.2.2.1 For any tests under the Register technical supervision, the chemical composition of ladle samples of each heat shall be determined by the steel maker and shall meet the requirements of the Register-approved specification or a standard.

7.2.2.2.3 Mechanical properties.

7.2.2.2.3.1 Bars of the same nominal diameter are to be presented for test in batches of 50 t or fraction thereof from the same heat.

Test specimens shall be taken from material heat treated in the same manner as intended for the finished chain.

7.2.2.2.3.2 Each batch of Grades R3S, R4, R4S and R5 shall be tested for hydrogen embrittlement. In case of continuous casting, test specimens representing both the beginning and the end of the charge shall be taken. In case of ingot casting, test samples representing two different ingots shall be taken.

7.2.2.2.3.2.1 Two tensile test specimens shall be taken from the central region of bar material which has been subjected to the heat treatment cycle intended to be used in production. A specimen with a diameter of 20 mm is preferred (consideration may be given to a diameter of 14 mm).

7.2.2.2.3.2.2 One of the specimens shall be tested within a maximum of 3 h after machining (for a 14 mm diameter specimen, the time limit is 1,5 h). Where this is not possible, the specimen shall be immediately cooled to -60°C after machining and kept at that temperature for a maximum period of 5 days.

7.2.2.2.3.2.3 The second specimen shall be tested after baking at 250°C for 4 h, alternatively 2 h for 14 mm diameter specimen.

7.2.2.2.3.2.4 A slow strain rate < 0,0003 s^{-1} shall be used during the entire test (this is approximately 10 min for the 20 mm diameter specimen). Tensile strength, elongation and reduction in area shall be reported.

2.2.2.3.2.5 The acceptance requirement for the test is:

$Z_1/Z_2 \geq 0,85$, where:

Z_1 − reduction of area without baking;

Z_2 − reduction of area after baking.

If the requirement $Z_1/Z_2 \geq 0,85$ is not achieved, the bar material may be subjected to a hydrogen degassing treatment. New tests shall be performed after degassing.

7.2.2.2.3.3 For all grades, one tensile and three charpy V-notch specimens shall be taken from each sample selected. The test specimens shall be taken at approximately one-third radius below the surface, as shown in Fig. 7.2.2.2.3.3 and prepared in accordance with the Section 2 requirements.

The results of all tests shall be in accordance with the appropriate requirements of Table 7.2.2.2.3.3.

7.2.2.2.4 Dimensional tolerances.

7.2.2.2.4.1 The diameter and roundness shall be within the tolerances specified in Table 7.2.2.2.4.1, unless otherwise agreed.

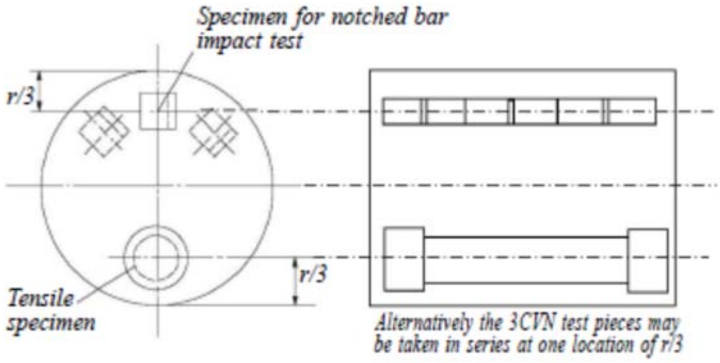


Fig. 7.2.2.2.3.3. Location of specimens. Steel bar, forging, casting.

Table 7.2.2.2.3.3 **Mechanical properties of mooring chain and accessories**

Grade	Yield stress, min, N/mm^2	Tensile strength, min, N/mm^2	, min, N/mm2 Elongation, min, %	Reduction in area, min, %	Impact tests KV		
					Test temperature °C,	Average energy, min, J	
						Base metal	Weld metal
R3	410	690	17	50	0 - 20	60 40	50 30
R3S	490	770	15	50	0 - 20	65 45	53 33
R4	580	880	12	50	-20	50	36
R4S	700	960	12	50	-20	56	40
R5	760	1000	12	50	-20	58	42

1. Aim value of yield to tensile ratio: 0,92 max.
2. At the option of the Register the impact test of Grade R3 and R3S may be carried out at either 0 or- 20ºC.
3. Reduction in area of cast steel shall be for Grades R3 and R3S: min 40 %; for R4, R4S and R5: min 35 per cent (refer to 7.2.2.4.4).
4. Aim maximum hardness for R4S is HB330 and R5 HB340.

Table 7.2.2.2.4.1

Nominal diameter, mm	Tolerance on diameter, mm	Tolerance on roundness, (d_{max} - d_{min}), mm
< 25	- 0 + 1,0	0,6
25-35	- 0 + 1,2	0,8
36-50	- 0 + 1,6	1,1
51-80	- 0 + 2,0	1,5
81-100	- 0 + 2,6	1,95
101-120	- 0 + 3,0	2,25
121-160	- 0 + 4,0	3,00
161-220	- 0 + 5,0	4,00

7.2.2.2.5 Non-destructive testing and repair..

7.2.2.2.5.1 Non-destructive testing shall be performed in accordance with the standards recognized by the Register such as those indicated below or equivalent:

ASTM E1444 and ДСТУ EN ISO 9934 or the applicable ISO or EN standards - magnetic particle testing (MT) of bars;

JIS Z2319 - magnetic leakage flux testing (MLFT);

ДСТУ ISO 15549 or the applicable ISO standard чи - eddy current testing (ET) of bars.

Non-destructive testing procedures, together with rejection/acceptance criteria shall be submitted to the Register for agreement.

7.2.2.2.5.2 Manufacturers shall prepare written procedures for non-destructive testing.

Non-destructive testing personnel shall be qualified and certified according to ДСТУ EN ISO 9712 or the applicable ISO or EN standards, ACCP or equivalent. Personnel qualification to an employer or responsible agency based qualification scheme as SNT-TC-1A may be accepted if the employer's written practice is reviewed and found acceptable and the level III is ASNT level III, ДСТУ EN ISO 9712 or the applicable ISO or EN standards - level III or ACCP professional level III and certified in the applicable method. Nondestructive testing operators shall be qualified to at least level II.

7.2.2.2.5.3 The manufacturer shall ensure that 100 % of bar material intended for either chain or fittings is subjected to ultrasonic testing at an appropriate stage of the manufacture to procedures approved by the Register and to the acceptance criteria required. The bars shall be free of pipe, cracks and flakes. If the end length of the delivered bars is not subjected to ultrasonic testing then it shall be agreed between the bar supplier and the chain manufacturer of what length of bar shall be removed from the ends. The details shall be documented in the approval of each bar supplier. Phased array ultrasonic testing procedures may be applied after its approval by the Register.

7.2.2.2.5.4 100 % of the bar material shall be tested by magnetic particle (MT) or eddy current (ET) or Magnetic magnetic leakage flux testing (MLFT) methods.

The bars shall be free of injurious surface imperfections such as seams, laps and rolled-in mill scale. Provided that their depth is not greater than 1 % of the bar diameter, longitudinal defects may be removed by grinding and blending to a smooth contour.

All bars supplied in a machined (peeled) condition shall be 100 % visually inspected. The Register shall also require 10 % to be inspected with magnetic particle testing (MT) or eddy current testing (ET) or magnetic leakage flux testing (MLFT), for longitudinal imperfections. The maximum depth of peeling shall be agreed and documented in the approval of each supplier by the Register.

7.2.2.2.5.5 The frequency of non-destructive testing may be reduced provided it is verified by statistical means that the required quality is consistently achieved.

7.2.2.2.5.6 Weld repair of bars is not permitted.

7.2.2.2.6 Marking.

7.2.2.2.6.1 Each bar shall be stamped with the steel grade designation and the charge number (or a code indicating the charge number) on one of the end surfaces.

7.2.2.3 Forged steel.

7.2.2.3.1 Manufacture.

7.2.2.3.1.1 Forged steels used for the manufacture of accessories shall be in compliance with the requirements of the Register-approved documentation with specifications and test reports.

Steel shall be manufactured by basic oxygen, electric furnace or such other process as may be specially approved by the Register. All steel shall be killed and fine grain treated. The austenitic grain size shall be 6 or finer (refer to ASTM E112 or equivalent grain size index in accordance with ISO 643 or the applicable ISO standard). Measurements for circular sections shall be taken at 1/3 radius. Measurements for non-circular sections shall be taken at 1/4*t*.

7.2.2.3.1.2 Steel for forgings intended for R4S and R5 chain shall be vacuum degassed. The austenitic grain size shall be 6 or finer (refer to ASTM E112 or equivalent grain size index in accordance with ДСТУ ISO 643 or the applicable ISO standard). Measurements for circular sections shall be taken at 1/3 radius. Measurements for non-circular sections shall be taken at 1/4*t*.

7.2.2.3.1.3 For steel intended for R4S and R5 accessories the following information shall be supplied by the steel manufacturer to the accessory manufacturer and the results included in the accessory documentation:

a) each heat shall be examined for non-metallic inclusions. The level of micro inclusions shall be quantified and assessed in accordance with the recognized national and international standards; to be sure inclusion levels are acceptable for the final product.

b) a sample from each heat shall be macroetched according to ASTM E381 or national equivalent, to be sure there is no injurious segregation or porosity.

c) hardenability data, according to ASTM A255 or national equivalent, shall be provided with each heat.

The results of the above tests are to be included in the accessory documentation.

7.2.2.3.2 2 Chemical composition (refer to **7.2.2.2.2**).

7.2.2.3.3 Heat treatment.

7.2.2.3.3.1 Finished forgings shall be properly heat treated in compliance with specification submitted and approved.

7.2.2.3.4 Mechanical properties.

7.2.2.3.4.1 The forgings shall comply with the mechanical properties given in Table 7.2.2.2.3.3 when properly heat treated.

7.2.2.3.5 Mechanical tests.

7.2.2.3.5.1 For test sampling, forgings of similar dimensions (diameters do not differ by more than 25 mm) originating from the same heat treatment charge and the same heat of steel shall be combined into one test unit. From each test unit one tensile and three impact test specimens shall be taken and tested.

The specimens shall be located according to Fig. 7.2.2.2.3.3 and the requirements of Section **2**.

7.2.2.3.5.2 Each heat of Grades R3S and R4 shall be tested for hydrogen embrittlement. In case of continuous casting, test samples representing both the beginning and the end of the charge shall be taken. In case of ingot casting, test samples representing two different ingots shall be taken.

7.2.2.3.5.2.1 Two tensile test specimens shall be taken from the central region of forged material which has been subjected to the heat treatment cycle intended to be used in production. A specimen with a diameter of 20 mm is preferred (use of specimens with a diameter of 14 mm is permitted upon agreement with the Register).

7.2.2.3.5.2.2 One of the specimens shall be tested within a maximum of 3 h after machining (for a 14 mm diameter specimen, the time limit is 1,5 h). Where this is not possible, the specimen shall be immediately cooled to - 60°C after machining and kept at that temperature for a maximum period of 5 days.

7.2.2.3.5.2.3 The second specimen shall be tested after baking at 250°C for 4 h, alternatively 2 h for 14 mm diameter specimen.

7.2.2.3.5.2.4 A slow strain rate (a relative elongation to design length) < 0,0003 s^{-1} shall be used during the entire test, until fracture occurs (this is approximately 10 min for the 20 mm diameter specimen).

7.2.2.3.5.2.5 When determining R3S and R4 grade chains' susceptibility to hydrogen embrittlement $Z_1/Z_2 > 0,85$, where Z_1 is reduction of area without baking and Z_2 is reduction of area after baking. If the requirement $Z_1/Z_2 > 0,85$ is not achieved, the bar material may be subjected to a hydrogen degassing treatment after agreement with the Register. New tests shall be performed after degassing.

7.2.2.3.6 Ultrasonic testing.

7.2.2.3.6.1 Non-destructive testing shall be performed in accordance with the standards recognized by the Register such as those indicated below:

ДСТУ EN 10228-1 or the applicable EN, ASTM A275 standards and ДСТУ EN ISO 9934-1 or the applicable ISO or EN standards - magnetic particle testing (MT) of forgings;

ДСТУ EN 10228-3 or the applicable EN, ASTM A388 standards and ДСТУ EN ISO 13588 or the applicable ISO or EN standards - ultrasonic testing (UT) of forgings.

Non-destructive testing procedures, together with rejection/acceptance criteria shall be submitted to the Register for agreement.

7.2.2.3.6.2 Manufacturers shall submit to the Register written procedures for non-destructive testing. Non-destructive testing personnel shall be qualified and certified according to ДСТУ EN ISO 9712 or the applicable ISO or EN standards, ACCP or equivalent. Personnel qualification to an employer or responsible agency based qualification scheme as SNT-TC-1A may be accepted if the employer's written practice is reviewed and found acceptable and the level III is ASNT level III, ДСТУ EN ISO 9712 or the applicable ISO or EN standards - level III or ACCP professional level III and certified in the applicable method. NDT operators shall be qualified to at least level II.

7.2.2.3.6.3 The forgings shall be subjected to 100 % ultrasonic testing and in compliance with the specification approved by the Register.

7.2.2.3.6.4 Defects on non-machined surfaces may be removed by grinding to a depth of 5 % of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces to a maximum depth of 0,8 mm in order to investigate spurious indications.

7.2.2.3.6.5 Welding repairs are not permitted.

7.2.2.3.7 Marking (refer to **7.2.2.2.6**).

7.2.2.4 Cast steel.

7.2.2.4.1 Manufacture.

7.2.2.4.1.1 Cast steel used for the manufacture of accessories shall be in compliance with the requirements of the Register-approved documentation with specifications and test reports.

Steel shall be manufactured by basic oxygen, electric furnace or such other process approved by the Register. All steel shall be killed and fine grain treated.

The austenitic grain size for R3, R3S and R4 grades shall be 6 or finer (refer to ASTM E112 or equivalent grain size index in accordance to ДСТУ ISO 643 or the applicable ISO standard). Measurements for circular sections shall be taken at 1/3 radius. Measurements for non-circular sections are to be taken at 1/4*t*.

7.2.2.4.1.2 Steel for castings intended for R4S and R5 grade chain accessories shall be vacuum degassed. The austenitic grain size shall be 6 or finer (refer to ASTM E112, or equivalent grain size index in accordance to ДСТУ ISO 643 or the applicable ISO standard). Measurements for circular sections shall be taken at 1/3 radius. Measurements for non-circular sections shall be taken at 1/4*t*.

7.2.2.4.1.3 For steel intended for R4S and R5 accessories the following information shall be supplied by the steel manufacturer to the accessory manufacturer and the results included in the accessory documentation:

a) each heat shall be examined for non-metallic inclusions.

The level of micro inclusions shall be quantified and assessed in accordance to the recognized national and international standards; to be sure inclusion levels are acceptable for the final product.

b) a sample from each heat shall be macro etched according to ASTM E381 or national equivalent, to be sure there is no injurious segregation or porosity.

c) hardenability data, according to ASTM A255 or national equivalent, shall be supplied with each heat.

The results of the above tests are to be included in the accessory documentation.

7.2.2.4.2 Chemical composition (refer to **7.2.2.2.2**).

7.2.2.4.3 Heat treatment. All castings shall be properly heat treated in comp-liance with specifications submitted and approved.

7.2.2.4.4 Mechanical properties.

7.2.2.4.4.1 The castings after heat treatment shall comply with the mechanical properties given in Table 7.2.2.3.3. The acceptance requirement for reduction in area is, however, reduced to 40 % for Grades R3 and R3S, and 35 % for Grades R4, R4S and R5.

7.2.2.4.5 Mechanical tests.

7.2.2.4.5.1 For test sampling, castings of similar dimensions originating from the same heat treatment charge and the same heat of steel shall be combined into one test unit. From each test unit one tensile and three impact test specimens shall be taken and tested.

The specimens shall be located according to Fig. 7.2.2.2.3.3 and the requirements of Section **2**.

7.2.2.4.6 Non-destructive testing and repair.

7.2.2.4.6.1 Non-destructive testing shall be performed in accordance with the standards recognized by the Register such as those indicated below, or equivalent:

ДСТУ EN 10228-1 or applicable EN, ASTM A275 standard and ДСТУ EN ISO 9934-1 - magnetic particle testing (MT) of castings;

ДСТУ EN 10228-3 or applicable EN, ASTM A388 standard and ДСТУ EN ISO 13588 or applicable ISO or EN standards - ultrasonic testing (UT) of castings.

Non-destructive testing procedures, together with rejection/acceptance criteria shall be submitted to the Register for agreement.

7.2.2.4.6.2 Manufacturer shall submit to the Register written procedures for non-destructive testing. Non-destructive testing personnel shall be qualified and certified according to ДСТУ EN ISO 9712 or applicable ISO or EN standards, ACCP equivalent. Personnel qualification to an employer or responsible agency based qualification scheme as SNT-TC-1A may be accepted if the employer's written practice is reviewed and found acceptable and the level III is ASNT level III, ДСТУ EN ISO 9712 or applicable ISO or EN standards - level III or ACCP professional level III and certified in the applicable method.

Non-destructive testing operators shall be qualified to at least level II.

7.2.2.4.6.3 The castings shall be subjected to 100 % ultrasonic testing and in compliance with the specification approved by the Register.

7.2.2.4.6.4 Defects on non-machined surfaces may be removed by grinding to a depth of 5 % of the nominal diameter. Grinding is not permitted on machined surfaces, except for slight inspection grinding on plane surfaces to a maximum depth of 0,8 mm in order to investigate spurious indications.

7.2.2.4.6.5 Where the repair entails removal of more than 5 % of the diameter or thickness, the defective area shall be repaired by welding. The excavations shall be suitably shaped to allow good access for welding. The resulting grooves shall be subsequently ground smooth and complete elimination of the defective material shall be verified by non-destructive testing.

7.2.2.4.6.6 Weld repairs are classified as major or minor. A weld repair is considered major when the depth of the groove prepared for welding exceeds 25 % of the diameter or thickness or 25 mm, whichever is smaller. All other weld repairs are considered minor.

7.2.2.4.6.7 Weld repairs may be conducted only after the approval by the Register. Reports submitted to the Register shall be accompanied by sketches or photographs showing the extent and positions of the repairs. A grain refining heat treatment shall be given to the whole casting prior to repairs. A post weld heat treatment of post-repair castings shall be carried out.

7.2.2.4.6.8 Minor and major weld repairs by the manufacturer shall be recorded on sketches and photographs showing the extent and positions of the repairs (before and after) and submitted to the Register.

7.2.2.4.6.9 All weld repairs shall be done by qualified welders using qualified procedures. Welders shall be qualified according to ДСТУ EN ISO 9606 or applicable ISO or EN standards, ASME IX, ASTM A488 or equivalent. Procedures shall be qualified according to ДСТУ EN ISO 15614 or applicable ISO or EN standards, ASME IX, ASTM A488 or equivalent with the following additional requirements: Charpy V notch impact tests with notch locations in weld metal, fusion line and heat affected zone + 2 mm and + 5 mm from fusion line, respectively. Test results shall meet the requirements of the Rules specified for the base metal.

7.2.2.4.7 Marking (refer to **7.2.2.2.6**).

7.2.2.5 Materials for studs.

7.2.2.5.1 Studs intended for stud link chain cable shall be made of steel corresponding to that of the chain or in compliance with specification submitted and approved by the Register.

In general, the carbon content shall not exceed 0,25 % if the studs shall be welded in place.

7.2.3 Design and chain manufacture.

7.2.3.1 Design.

7.2.3.1.1 Drawings accompanied by design calculations, giving the detailed design of chain and accessories made by, or supplied through, the chain manufacturer shall be submitted to the Register for approval.

Typical designs are given in ISO 1704 (in Ukraine ДСТУ 3074).

For studless chain the shape and proportions shall comply with the requirements of this Section.

Application of studless chains and accesories of designs other than specified in thist Section is considered by the Register to be application of new or non-standard designs of chains, shackles or fittings. For application of the latter results of fatigue and corrosion fatigue tests shall be submitted. Documentation specifying the characteristics of the chain and fittings shall be approved by the Register.

7.2.3.1.2 In addition, for stud link chain, drawings showing the detailed design of the stud shall be submitted for information. The stud shall give an impression in the chain link which is sufficiently deep to secure the position of the stud, but the combined effect of shape and depth of the impression shall not cause any harmful notch effect or stress concentration in the chain link.

7.2.3.1.3 Machining of Kenter shackles shall result in a fillet radius minimum 3 % of a nominal link diameter.

7.2.3.2 Chain cable manufacturing process.

7.2.3.2.1 General.

7.2.3.2.1.1 1 Offshore mooring chains shall be manufactured in continuous lengths by flash butt welding and shall be heat treated in a continuous furnace.

Batch heat treatment is not permitted, except in special circumstances where short lengths of chain are delivered, such as chafing chain.

7.2.3.2.1.2 The use of joining shackles to replace defective links is subject to the written approval of the end purchaser in terms of the number and type permitted.

The use of connecting common links is restricted to 3 links in each 100 m of chain.

7.2.3.2.2 Chain cable manufacturing process records.

7.2.3.2.2.1 Records of bar heating, flash welding and heat treatment shall be made available for inspection by the Register.

7.2.3.2.3 Bar heating.

7.2.3.2.3.1 Bars for links shall be heated by electric resistance, induction or in a furnace.

7.2.3.2.3.2 For electric resistance heating, the heating phase shall be controlled by an optical heat sensor. The controller shall be checked at least once every 8 h and records made.

7.2.3.2.3.3 For furnace heating, the heat shall be controlled and the temperature continuously recorded using thermocouples in close proximity to the bars. The controls shall be checked at least once every 8 h and records made.

7.2.3.2.4 Flash welding of chain cable.

7.2.3.2.4.1 The following welding parameters shall be controlled during welding of each link:

platen motion;

current as a function of time;

hydraulic pressure.

7.2.3.2.4.2 The controls shall be checked at least every 4 h and records made.

7.2.3.2.5 Heat treatment of chain cable.

7.2.3.2.5.1 Chain shall be austenitized, above the upper transformation temperature, at a combination of temperature and time within the limits established by the manufacturer.

7.2.3.2.5.2 When applicable, chain shall be tempered at a combination of temperature and time within the limits established by the manufacturer.

Cooling after tempering shall be appropriate to avoid temper embrittlement.

7.2.3.2.5.3 Temperature and time or temperature and chain speed shall be controlled and continuously recorded.

7.2.3.2.5.4 Grain determination shall be made for the final product. The austenitic grain size for R3, R3S, R4, R4S and R5 shall be 6 or finer (refer to ASTM E112 or equivalent grain size index in accordance to ДСТУ ISO 643 or applicable ISO or EN standards). Measurements for circular sections shall be taken at surface, 1/3 radius and centre for the base material, HAZ and weld.

7.2.3.2.6 Mechanical properties.

7.2.3.2.6.1 The mechanical properties of finished chain and accessories shall be in accordance with Table 7.2.2.2.3.3. For the location of test specimens refer to Fig. 7.2.3.2.6.1.

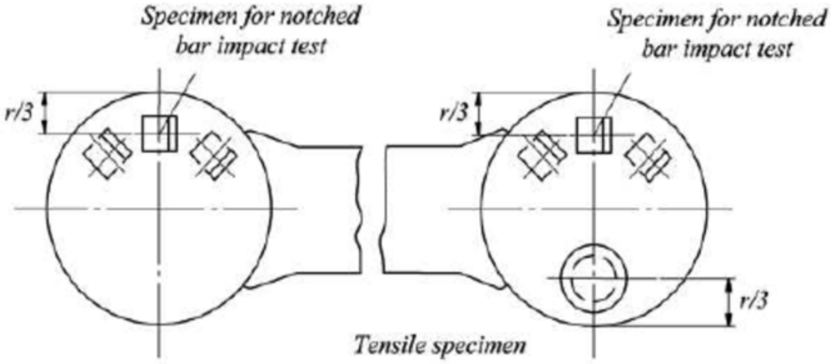


Fig. 7.2.3.2.6.1
Sampling of chain.

7.2.3.2.7 Proof and breaking test loads.

7.2.3.2.7.1 Chains and accessories shall withstand the proof and break test loads given in Table 7.2.3.2.7.1.

Table 7.2.3.2.7.1 **Formulas for proof and break test loads, weight and length over 5 links**

Test load, kN	**Grade R3 stud link**	**Grade R3S stud link**	**Grade R4 stud link**	**Grade R4S stud link**	**Grade R5 stud link**
Proof	$0{,}0148d^2(44 - 0{,}08d)$	$0{,}0180d^2(44 - 0{,}08d)$	$0{,}0216d^2(44 - 0{,}08d)$	$0{,}0240d^2(44 - 0{,}08d)$	$0{,}0251d^2(44 - 0{,}08d)$
Break	$0{,}0223d^2(44 - 0{,}08d)$	$0{,}0249d^2(44 - 0{,}08d)$	$0{,}0274d^2(44 - 0{,}08d)$	$0{,}0304d^2(44 - 0{,}08d)$	$0{,}0320d^2(44 - 0{,}08d)$
Test load, kN	**Grade R3 studless**	**Grade R3S studless**	**Grade R4 studless**	**Grade R4S studless**	**Grade R5 studless**
Proof	$0{,}0148d^2(44 -0{,}08d)$	$0{,}0174d^2(44 - 0{,}08d)$	$0{,}0192d^2(44 - 0{,}08d)$	$0{,}0213d^2(44 - 0{,}08d)$	$0{,}0223d^2(44 - 0{,}08d)$
Break	$0{,}0223d^2(44 -0{,}08d)$	$0{,}0249d^2(44 - 0{,}08d)$	$0{,}0274d^2(44 - 0{,}08d)$	$0{,}0304d^2(44 - 0{,}08d)$	$0{,}0320d^2(44 - 0{,}08d)$
Chain weight, kg/m	Stud link = $0{,}0219d^2$				
Chain weight, kg/m	Studless chain Weight calculations for each design shall be submitted				
Pitch length	Five link measure				
Minimum	$22d$				
Maximum	$22{,}55d$				

7.2.3.2.8 Non-destructive testing.

7.2.3.2.8.1 All finished chains shall have a proper quality to be ensured by the manufacturer. Each link shall be subjected to non-destructive testing in compliance with 7.2.4.5 using the Register-approved procedures.

7.2.3.2.9 Dimensions and dimensional tolerances.

7.2.3.2.9.1 The shape and proportion of links and accessories shall conform to ISO 1704 (in Ukraine ДСТУ 3074) or the relevant documentation approved by the Register.

7.2.3.2.9.2 The following tolerances are applicable to links:

.1 the negative tolerance on the nominal diameter measured at the crown:

up to 40 mm nominal diameter – 1 mm; over 40 up to 84 mm nominal diameter – 2 mm;

over 84 up to 122 mm nominal diameter – 3 mm;

over 122 up to 152 mm nominal diameter – 4 mm;

over 152 up to 184 mm nominal diameter – 6 mm;

over 184 up to 222 mm nominal diameter – 7,5 mm.

Note. The cross sectional area at the crown shall have no negative tolerance. For diameters of 20 mm or greater, the plus tolerance may be up to 5 % of the nominal diameter. For diameters less than 20 mm the plus tolerance shall be agreed with the Register.

The cross sectional area at the crown shall be calculated using the average of the diameters with negative tolerance and plus tolerance, measurements shall be taken from at least 2 locations approximately 90° apart;

.2 diameter measured at locations other than the crown:

the diameter shall have no negative tolerance;

the plus tolerance may be up to 5 % of the nominal diameter except at the butt weld where it shall be in accordance to manufacturer's specification, which shall be agreed with the Register.

For diameters less than 20 mm, the plus tolerance shall be agreed with the Register during survey.

.3 the allowable manufacturing tolerance on a length of five links shall be +2,5 %, but shall not be negative;

.4 all other dimensions are subject to a manufacturing tolerance of +2,5 %, provided always that all parts fit together properly;

.5 the tolerances for stud link and studless common links shall be measured in accordance with Tables and Figs. 7.2.3.2.9.2-1 and 7.2.3.2.9.2-2 accordingly;

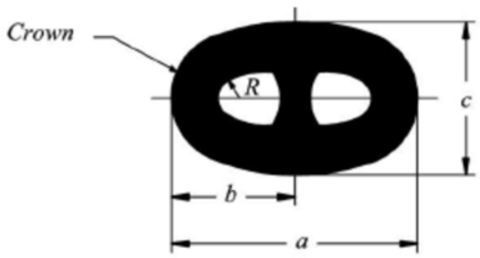


Fig. 7.2.3.2.9.2-1
Stud link – the internal link radii R and external radii shall be uniform.

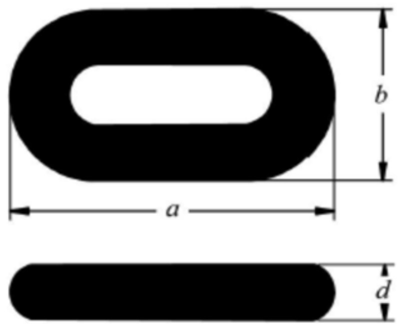


Fig. 7.2.3.2.9.2-2
Studless – the internal link radii R and external radii shall be uniform

Table 7.2.3.2.9.2-1 **Proportions dimensions and tolerances for stud links**

Dimensions – refer to Fig. 7.2.3.2.9.2-1)	Parameters	Nominal dimension	Minus tolerance	Plus tolerance
1	2	3	4	5
a	Link length	6d	0,15d	0,15d
b	Link half length	*a**/2	0,1d	0,1d
c	Link width	3,6d	0,09d	0,09d
e	Stud angular misalignment	0 degrees	4 degrees	4 degrees
R	Inner radius	0,65d	0	—
Note: d – nominal diameter of chain, *a** – actual link length.				

Table 7.2.3.2.9.2-2 **Proportions dimensions and tolerances for studless links**

Dimensions – refer to Fig. 7.2.3.2.9.2-2)	Parameters	Nominal dimension	Minus tolerance	Plus tolerance
a	Link length	6d	0,15d	0,15d
b	Link width	3,35d	0,09d	0,09d
R	Inner radius	0,60d	0	—
Notes: 1. d – nominal diameter of chain. 2. Other dimension ratios are allowed in accordance with national or international standards, the application of which shall be agreed with the Register.				

.6 for stud link chains, the studs shall be located in the links centrally and at right angles to the sides of the link. The tolerances are determined in compliance with Table 7.2.3.2.9.2-1 and Fig. 7.2.3.2.9.2-1 provided that the stud fits snugly and its ends lie flush against the inside of the link.

7.2.3.2.10 Stud link chain - welding of studs.

7.2.3.2.10.1 A welded stud may be accepted for grade R3 and R3S chains.

Welding of studs in Grades R4, R4S and R5 chain is not permitted unless approved by the Register.

7.2.3.2.10.2 Where studs are welded into the links this shall be completed before the chain is heat treated.

7.2.3.2.10.3 The stud ends shall be a good fit inside the link and the weld shall be confined to the stud end opposite to the flash butt weld.

The full periphery of the stud end shall be welded unless otherwise approved.

7.2.3.2.10.4 Welding of studs both ends is not permitted unless approved by the Register.

7.2.3.2.10.5 The welds shall be made by qualified welders using the Register-approved procedure and low-hydrogen approved consumables.

7.2.3.2.10.6 The size of the fillet weld shall as a minimum be as per API Specification 2F (refer to Fig. 7.2.3.2.10.6).

7.2.3.2.10.7 The welds shall be of good quality and free from defects such as cracks, lack of fusion, gross porosity and undercuts exceeding 1 mm.

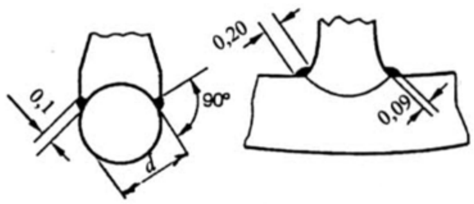


Fig. 7.2.3.2.10.6

7.2.3.2.10.8 All stud welds shall be visually tested. At least 10 % of all stud welds within each length of chain shall be examined by dye penetrant or magnetic particles after proof testing. If unacceptable defects are found, all stud welds in that length shall be examined.

7.2.3.2.11 Connecting common links (splice links)**.**

7.2.3.2.11.1 Single links to substitute for test links or defective links without the necessity for reheat treatment of the whole length shall be made in accordance with the Register-approved procedure. Separate approvals are required for each grade of chain and the tests shall be made on the maximum size of chain for which approval is sought.

7.2.3.2.11.2 Manufacture and heat treatment of connecting common link shall not affect the properties of the adjoining links.

The temperature reached by these links shall nowhere exceed 250°C.

7.2.3.2.11.3 Each link shall be subjected to the appropriate proof load and non-destructive testing as detailed in Table **7.2.3.2.7.1** and **7.2.4.5**, respectively.

A second link shall be made identical to the connecting common link; the link shall be tested according to **7.2.4.4** and **7.2.4.5**.

7.2.3.2.11.4 Each connecting common link shall be marked either;

on the stud for stud link chain or,

on the outer straight length on the side opposite the flash butt weld for studless chain. This marking shall be in accordance with **7.2.4.7** plus a unique number for the link. The adjoining links shall also be marked on the studs or straight length as above.

7.2.4 Testing of finished chain.

7.2.4.1 General.

7.2.4.1.1 The present requirements apply to, but are not limited to common stud and studless links, end links, enlarged end links and connecting common links (splice links).

7.2.4.1.2 All chain shall be subjected to proof load tests, sample break load tests and sample mechanical tests after final heat treatment in the presence of the Register representative.

Where the manufacturer has a procedure to record proof loads and the Register representative is satisfied with the adequacy of the recording system, he does not need to witness all proof load tests.

The Register representative shall satisfy himself that the testing machines are calibrated and maintained in a satisfactory condition.

Prior to inspection the chain shall be free from scale, paint or other coating and shall have a suitably prepared surface as per the applied non-destructive testing standard.

The chain shall be sand- or shot blast to meet this requirement.

7.2.4.2 Proof and break load tests.

7.2.4.2.1 The entire length of chain shall withstand the proof load specified in Table 7.2.3.2.7.1 without fracture and shall not crack in the flash weld. The load applied shall not exceed the proof load by more than 10 % when stretching the chain. Where plastic straining is used to set studs, the applied load shall not be greater than that qualified in the initial chain tests during recognition of the manufacturer**.**

7.2.4.2.2 A break-test specimen consisting of at least 3 links shall be either taken from the chain or produced at the same time and in the same manner as the chain.

The test frequency shall be based on tests at sampling intervals according to Table 7.2.4.2.2 provided that every cast is represented.

Each specimen shall be capable of withstanding the break load specified without fracture and shall not crack in the flash weld. It shall be considered acceptable if the specimen is loaded to the specified value and maintained at that load for 30 s.

Table 7.2.4.2.2 **Frequency of break and mechanical tests**

Nominal chain diameter, mm	Maximum sampling interval, m
min - 48	91
49 - 60	110
61 - 73	131
74 - 85	152
86 - 98	175
112 - 124	222
125 - 137	250
138 - 149	274
150 - 162	297
163 - 175	322
176 - 186	346
187 - 198	370
199 - 210	395
211 - 222	420

7.2.4.2.3 For chain diameters over 100 mm, alternative break-test proposals to the above break-test may be considered whereby a one link specimen is used.

Alternatives shall be approved by the Register, every heat shall be represented, the test frequency shall be in accordance with Table 7.2.4.2.2, and it shall be demonstrated and proven that the alternative test represents an equivalent load application to the three link test.

7.2.4.2.4 If the loading capacity of the testing machine is insufficient, an alternative load testing machine shall be used that does have sufficient capacity (e.g. two loading machines in parallel), provided the testing and calibration procedure are agreed with the Register.

7.2.4.3 Dimensions and dimensional tolerances.

7.2.4.3.1 After proof load testing measurements shall be taken on at least 5 % of the links in accordance with **7.2.3.2.7.1**.

7.2.4.3.2 The entire chain shall be checked for the length, five links at a time. By the five link check the first five links shall be measured. From the next set of five links, at least two links from the previous five links set shall be included. This procedure shall be followed for the entire chain length.

The measurements shall be taken preferably while the chain is loaded to 5 to 10 % of the minimum proof load. The tolerances for the 5 link measurements are indicated in Table 7.2.3.2.7.1, any deviations from the 5 link tolerances shall be agreed with the Register. The links held in the end blocks may be excluded from this measurement.

7.2.4.3.3 Chain dimensions shall be recorded and the information retained on file. 7.2.4.4 Mechanical tests.

7.2.4.4.1 Links of samples detached from finished, heat treated chain shall be sectioned for determination of mechanical properties. A test unit shall consist of one tensile and nine impact specimens**:**

the tensile specimen shall be taken in the side opposite the flash weld and three impact specimens shall be taken across the unwelded side;

three impact specimens shall be taken from the bend region;

three impact specimens shall be taken across the flash weld with the notch centred in the middle.

7.2.4.4.2 The test frequency shall be in accordance with Table 7.2.4.2.2 provided that every cast is represented. Mechanical properties shall meet the requirements of Table 7.2.2.2.3.3.

7.2.4.4.3 The frequency of impact testing in the bend may be reduced at the discretion of the Register provided it is verified by statistical means that the required toughness is consistently achieved.

7.2.4.4.4 Hardness tests shall be carried out on finished chain. The frequency and locations shall be agreed with the Register. The recorded values are for information only and used as an additional check to verify that the heat treatment process has been stable during the chain production.

7.2.4.5 Non-destructive testing.

7.2.4.5.1 All surfaces of every link shall be visually tested and measured, sizes and mutual mobility of elements and products shall be checked.

Burrs, irregularities and rough edges shall be contour ground. Links shall be free from mill defects, surface cracks, dents and cuts, especially in the vicinity where gripped by clamping dies during flash welding. Studs shall be securely fastened.

Chain shall be positioned in order to have good access to all surfaces. In order to allow optimal access to the surface area it is recommended that chain be hung in the vertical position, however access to inspect the interlink area may only be possible with the chain in the horizontal position.

7.2.4.5.2 Non-destructive testing shall be performed in accordance with recognized standards and procedures, together with the Register-approved acceptance/rejection criteria. Manufacturers shall submit to the Register written procedures for non-destructive testing. Non-destructive testing personnel shall be qualified and certified according to ДСТУ EN ISO 9712 or the applicable ISO or EN standards, ACCP or equivalent. Personnel qualification to an employer or responsible agency based qualification scheme as SNT-TC-1A may be accepted if the employer's written practice is reviewed and found acceptable and the level III is ASNT level III, ДСТУ EN ISO 9712 or the applicable ISO or EN standards, level III or ACCP professional level III and certified in the applicable method.

Non-destructive testing operators shall be qualified to at least level II.

7.2.4.5.3 3 Magnetic particle testing approved by the Register shall be employed to examine the flash welded area including the area gripped by the clamping dies. The relevant procedures and equipment shall be agreed with the Register. Additionally, 10 % of links shall be tested on all accessible surfaces. Link surfaces and the surface at the flash weld shall be free from cracks, lack of fusion and gross porosity. Testing shall be performed in accordance with ASTM E709 or another recognized standard (e.g. ДСТУ EN ISO 9934 or the applicable ISO or EN standards) using wet continuous fluorescent magnetization technique.

Links shall be free from relevant linear indications exceeding 1,6 mm in transverse direction, relevant linear indications exceeding 3,2 mm in longitudinal direction and relevant non-linear indications exceeding 4,8 mm.

7.2.4.5.4 Ultrasonics shall be employed to examine the flash weld fusion. Procedures used shall be submitted to the Register for approval. Procedures and equipment shall be used in accordance with the approved documentation. On-site calibration standards for chain configurations shall be approved. Frequency of examination shall be every link.

The flash weld shall be free from defects causing ultrasonic back reflections equal to or greater than the calibration standard. The flash butt welds shall be ultrasonic tested (UT) in accordance with ASTM E587 or another recognized standard using single probe, angle-beam shear waves in the range from 45 to 70°.

Single probe technique has limitations as far as testing of the central region is concerned and the flash weld imperfections such as flat spots may have poor reflectivity. Where it is deemed necessary, detectability of imperfections may need to be carried out by using a tandem technique, TOFD or phased array.

7.2.4.5.5 Stud welds, if used, shall be visually inspected. The toes of the fillets shall have a smooth transition to the link with no undercuts exceeding 1,0 mm. Additionally, at least 10 % of the stud welds distributed through the length shall be dye penetrant tested according to ASTM E1417 or magnetic particle tested according to ASTM E1444 or equivalent. Cracks, lack of fusion or gross porosity are not acceptable. If defects are found, testing shall be extended to all stud welds in that length.

7.2.4.6 Retest and repair criteria**.**

7.2.4.6.1 If the length over 5 links is short, the chain may be stretched by loading above the proof test load specified provided that the applied load is not greater than that approved by the Register for the given chain and that only random lengths of the chain need stretching.

If the length exceeds the specified tolerance, the over length chain links shall be cut out and **7.2.4.6.2** shall apply.

7.2.4.6.2 If single links are found to be defective or not meet other applicable requirements, defective links may be cut out and a connecting common link inserted in their place. The individual heat treatment and insertion procedure of connecting common links shall be agreed with the Register.

Other methods for repair are subject to the written approval of the Register and the end purchaser. Weld repair of chain is not permitted.

7.2.4.6.3 If a crack, cut or defect in the flash weld are found by visual testing or magnetic particle testing, it shall be ground down no more than 5 % of the link diameter in depth and streamlined to provide no sharp contours.

The final dimensions shall still conform to the recognized standards and/or other documentation agreed with the Register.

7.2.4.6.4 If unacceptable interior flash weld defects are detected during ultrasonic testing, the link is subject to replacement in accordance with **7.2.4.6.2**.

7.2.4.6.5 If a link diameter, length, width and stud alignment do not conform to the required dimensions, these shall be compared to the dimensions of 40 more links; 20 on each side of the affected link.

If a single particular dimension fails to meet the required dimensional tolerance in more than 2 of the sample links, all links shall be examined.

Replacement of affected links, refer to **7.2.4.6.2**.

7.2.4.6.6 If a break load test fails, the Register representative carrying out technical supervision shall be informed in a timely manner, the case shall be recorded and the relevant explanations shall be submitted to the Register representative.

Two additional break test specimens representing the same sampling length of the chain (refer to Table 7.2.4.2.2) shall be subjected to the break load test.

Based upon satisfactory results of the additional tests and the results of the failure investigation, it may be decided what lengths of chain can be accepted. Failure of either of both additional tests will result in rejection of the sampling length of the chain represented.

For replacement, refer to **7.2.4.6.2**.

7.2.4.6.7 If a proof load test fails, the Register representative performing technical supervision shall be informed in a timely manner and the case shall be recorded. In the event that two or more links in the proof loaded length fail, that section of proof loaded length shall be rejected.

The above failure investigation shall be carried out especially with regard to the presence in other lengths of factors or conditions (refer to Table 7.2.4.2.2) thought to be causal to failure.

7.2.4.6.8 In addition to the above failure investigation, a break test specimen shall be taken from each side of the one failed link, and subjected to the breaking test.

Where multiple chains are produced simultaneously, it is allowed that the preceding flash butt welded link and subsequent flash butt welded link are on an alternative chain length or the other end of the chain length. In such cases the Register requires that two additional break tests shall be taken from the lengths of chain that include the preceding and subsequent welded links.

Based upon satisfactory results of both break tests and the results of the failure investigation, it may be decided what length of chain can be considered for acceptance.

Failure of either or both breaking tests will result in rejection of the same proof loaded length. Replacement of defective links shall be in accordance with **7.2.4.6.2**.

If the investigation identifies defects in the flash butt weld or a lower strength flash weld "a glue-weld" is found, additional non-destructive testing such as phased array ultrasonic testing shall be carried out to identify if other links are affected. A full assessment of the flash butt welding machine shall be carried out, together with assessment of the condition of the bar ends prior to welding.

7.2.4.6.9 If the results of tensile specimens testing are unsatisfactory, re-tests shall be conducted according to **1.3.4.2**.

Failure to meet the specified requirements of either or both additional tests will result in rejection of the sampling length of chain represented and **7.2.4.6.2** shall apply.

7.2.4.6.10 If the results of impact test specimens testing are unsatisfactory, re-tests shall be conducted according to **1.3.4.2**.

Failure to meet the requirements will result in rejection of the sampling length represented and **7.2.4.6.2** shall apply.

7.2.4.7 Marking.

7.2.4.7.1 The chain shall be marked at the following places:

at each end;

at intervals not exceeding 100 m;

on connecting common links;

on links next to shackles or connecting common links.

7.2.4.7.2 All the marked links shall be stated on the Certificate, and the marking shall make it possible to recognize leading and tail end of the chain. In addition to the above required marking, the first and last common link of each individual charge used in the continuous length shall be traceable and adequately marked.

The marking shall be permanent and legible throughout the expected lifetime of the chain.

7.2.4.7.3 The chain shall be marked on the studs as follows:

chain grade;

certificate No.;

Register stamp.

7.2.4.7.4 The Certificate number may be exchanged against an abbreviation or equivalent. If so, this shall be stated in the Certificate.

7.2.4.7.5 The chain Certificate shall contain information on number and location of connecting common links.

The Certificate number and replacement link number may be exchanged against an abbreviation or equivalent. If so, this shall be stated in the Certificate.

7.2.4.8 Documenation.

7.2.4.8.1 A complete chain inspection and testing report in booklet form shall be provided by the chain manufacturer for each continuous chain length. This booklet shall include all dimensional checks, test and inspection reports, non-destructive testing reports, process records, photographs as well as any nonconformity, corrective action and repair work.

7.2.4.8.2 Individual Certificate shall be issued for each continuous single length of chain.

7.2.4.8.3 All accompanying documents, appendices and reports shall carry reference to the original Certificate number.

7.2.4.8.4 The manufacturer shall be responsible for storing, in a safe and retrievable manner, all the docu-mentation produced for a period of at least 10 years.

7.2.5 Testing and inspection of accessories.

7.2.5.1 General.

7.2.5.1.1 These requirements apply but not limited to mooring equipment accessories such as detachable connecting links (shackles), detachable connecting plates (triplates), end shackles and swivel shackles, and subsea connectors.

7.2.5.1.2 All accessories shall be subjected to proof load tests, sample break load tests and sample mechanical tests after final heat treatment in the presence of the Register representative.

Where the manufacturer has a procedure to record proof loads and the Register representative is satisfied with the adequacy of the recording system, he need not witness all proof load tests.

The Register representative shall satisfy himself that the testing machines are calibrated and maintained in a satisfactory condition. Prior to testing and inspection the Register representative shall make sure that the chain accessories are free from scale, paint or other coating.

7.2.5.1.3 For accessory production a Manufacturing Procedure Specification (MPS) shall be submitted to the Register that details all critical aspects of accessory production, casting, forging, heat treating (including arrangement and spacing of components in the heat treatment furnaces), quenching, mechanical testing, proof and break loading and non-destructive testing.

7.2.5.2 Proof and break load tests.

7.2.5.2.1 All accessories shall be subjected to the proof load specified for the corresponding stud link chain.

7.2.5.2.2 Chain accessories shall be tested at the break load prescribed for the grade and size of chain for which they are intended.

At least one accessory out of every batch or every 25 accessories, whichever is less, shall be tested.

For individually produced, individually heat treated, accessories or accessories produced in small batches (less than 5), alternative testing shall be carried out. Alternative testing shall be approved by the Register and the following additional conditions shall apply:

.1 alternative testing is described in a written procedure and manufacturing procedure specification (MPS);

.2 a finite element analysis is provided at the break load and demonstrates that the accessory has a safety margin over and above the break load of the chain;

.3 strain age testing (as per procedure approved by the Register) is carried out on the material grade produced to the same parameters at the time of qualification;

.4 if an accessory is of a large size that will make heat treating in batches unfeasible or has a unique design, strain gauges shall be applied during the proof and break load tests during initial qualification and during production. The strain gauge results from production shall be comparable with the results from qualification.

7.2.5.2.3 A batch is defined, in compliance with **7.2.2.3** and **7.2.2.4**, as accessories that originate from the same heat treatment charge and the same heat of steel.

7.2.5.2.4 The accessories which have been subjected to the break load test shall be destroyed and not used as part of an outfit, with the exceptions given in **7.2.5.2.5**.

7.2.5.2.5 Where the accessories are of an increased dimension or alternatively a material with higher strength characteristics is used, they may be included in the outfit on agreement with the Register, provided that:

.1 the accessories are successfully tested at the prescribed breaking load appropriate to the chain for which they are intended;

.2 it is verified by procedure tests that such accessories are so designed that the breaking strength is not less than 1,4 times the prescribed breaking load of the chain for which they are intended;

.3 strain age properties have been carried out on the material grade produced to the same parameters;

.4 strain gauges have been applied during the break load test in the high stress locations to monitor that the strains stay within allowable limits.

7.2.5.3 Dimensions and dimensional tolerances.

7.2.5.3.1 At least one accessory (of the same type, size and nominal strength) out of 25 shall be checked for dimensions after proof load testing.

The manufacturer shall provide a statement indicating compliance with the purchaser's requirements.

7.2.5.3.2 The following tolerances are applicable to accessories:

.1 nominal diameter: +5 %, - 0 %;

.2 other dimensions**:** ±2%**.**

These tolerances do not apply to machined surfaces.

7.2.5.4 Mechanical tests.

7.2.5.4.1 Accessories shall be subjected to mechanical testing as described in **7.2.2.3** and **7.2.2.4**.

The specimens shall be taken from proof loaded full size accessories that have been heat treated with the production accessories they represent.

At least one accessory out of every batch or every 25 accessories, whichever is less, shall be tested. Hardness tests shall be carried out on finished accessories. The frequency and locations shall be agreed with the Register. The recorded values are for information only and used as an additional check to verify that the heat treatment process has been stable during the accessory production.

The use of separate representative coupons is not permitted except as indicated in **7.2.5.4.4**.

7.2.5.4.2 2 Test location of forged shackles.

Forged shackle bodies and forged Kenter shackles shall have a set of three impact tests and a tensile test taken from the crown of the shackle. Tensile tests on smaller diameter shackles can be taken from the straight part of the shackle, where the geometry does not permit a tensile specimen from the crown.

The tensile properties and impact values shall meet the requirements of Table 7.2.2.2.3.3 in the locations specified in Fig. 7.2.2.2.3.3, with the Charpy pieces on the outside radius.

7.2.5.4.3 Test location of cast shackles.

The locations of mechanical tests of cast shackles and cast Kenter shackles can be taken from the straight part of the accessory. The tensile properties and impact values shall meet the requirements of Table 7.2.2.2.3.3 in the locations specified in Fig. 7.2.2.2.3.3.

7.2.5.4.4 The locations of mechanical tests of other accessories with complex geometries shall be agreed with the Register. Rolled plates shall be tested to the standard to which they are produced.

7.2.5.4.5 5 For individually produced (heat treated) accessories or accessories produced in small batches (less than 5), alternative testing can be proposed to the Register. Each proposal for alternative testing shall be detailed by the manufacturer in a written procedure and submitted to the Register.

The following additional conditions may apply:

.1 if separately forged or cast coupons are used, they shall have a cross-section and, for forged coupon, a reduction ratio similar to that of the accessories represented, and shall be heat treated in the same furnace by the same technological procedure, as the actual forgings or castings. Thermocouples shall be attached to the coupon and to the accessories;

.2 if separately forged or cast coupons' application is agreed with the Register, the above provisions shall be confirmed with the relevant scope of testing**.**

7.2.5.4.6 A batch, in accordance with **7.2.2.3** and **7.2.2.4** is defined as accessories that originate from the same heat treatment charge and the same heat of steel.

7.2.5.4.7 Mechanical tests of pins shall be taken as per Fig. 7.2.2.2.3.3 from the mid-length of a sacrificial pin of the same diameter as the final pin. For oval pins the diameter taken shall represent the smaller dimension.

Mechanical properties can be determined on the extended pin.

The extended part of the pin shall be of the same diameter as the ready pin and shall consist of the tested metal and the buffer part located on one side (refer to Fig. 7.2.5.4.7).

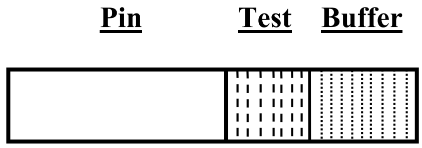


Fig. 7.2.5.4.7 Buffer and test piece location

7.2.5.5 Non-destructive testing and proof load testing. 7.2.5.5.1 ll chain accessories shall be subjected to a final visual testing and measurement. Special attention shall be paid to machined surfaces and high stress regions. Prior to inspection, chain accessories shall have a suitably prepared surface as per the applied non-destructive testing standard. All nonmachined surfaces shall be sand or shot blasted to permit a thorough examination.

Where applicable, accessories shall be dismantled for inspection of internal surfaces. All accessories shall be checked by magnetic particles, dye penetrant and ultrasonic testing.

The acceptance/rejection criteria of complying with the design documentation approved by the Register shall be met in full**.**

7.2.5.5.2 Testing shall be performed in accordance with the standards, such as those indicated below:

ДСТУ EN 10228-1, ДСТУ ISO 4986 or the applicable ISO or EN standards and ASTM A275, IACS №69 - magnetic particle testing (MT) of forgings;

ASTM A609 and ДСТУ EN ISO 13588 or the applicable ISO or EN standards - ultrasonic testing (UT) of forgings;

ASTM E709 - magnetic particle testing (MT) of castings;

ASTM A609 and ДСТУ EN ISO 13588 or the applicable ISO or EN standards - magnetic particle testing (MT) of castings.

The procedures recognized by the Register, including acceptance/rejection criteria, shall be submitted to the Register for review.

Manufacturers shall submit to the Register written procedures for non-destructive testing. Nondestructive testing personnel shall be qualified and certified according to ДСТУ EN ISO 9712 or the applicable ISO or EN standards, ACCP or equivalent. Personnel qualification to an employer or responsible agency based qualification scheme as SNT-TC-1A may be accepted if the employer's written practice is reviewed and found acceptable and the level III is ASNT level III, ДСТУ EN ISO 9712 or the applicable ISO or EN standards, level III or ACCP professional level III and certified in the applicable method.

Non-destructive testing operators shall be qualified to at least level II.

7.2.5.5.3 The manufacturer shall provide a statement that non-destructive testing has been carried out with satisfactory results. This statement shall include a brief reference to the techniques and to the operator's qualification.

7.2.5.5.4 Weld repairs of finished accessories are not permitted.

7.2.5.6 Test failures.

7.2.5.6.1 In the event of a failure of any test the entire batch represented shall be rejected unless the cause of failure has been determined and it can be demonstrated to the Register representative's satisfaction that the condition causing the failure is not present in any of the remaining accessories.

7.2.5.7 Marking.

7.2.5.7.1 A chain grade shall be marked on each accessory.

7.2.5.7.2 The Certificate number may be exchanged against an abbreviation or equivalent. If so, this shall be stated in the Certificate.

7.2.5.8 Documentation.

7.2.5.8.1 A complete inspection and testing report in booklet form shall be provided by the manufacturer for each order.

This booklet shall include all dimensional checks, test and inspection reports, non-destructive testing reports, process records and example photographs of components positioned in furnaces, as well as any nonconformity, corrective action and repair work.

7.2.5.8.2 Each type of accessories shall be covered by the separate Manufacturer's Certificate.

7.2.5.8.3 All accompanying documents, appendices and reports shall carry reference to the original Certificate number.

7.2.5.8.4 The manufacturer shall be responsible for storing, in a safe and retrievable manner, all documentation produced for a period of at least 10 years.

7.2.6 Chafing chain for single point mooring arrangements.

7.2.6.1 General.

7.2.6.1.1 The present requirements apply to short lengths (approximately 8 m) of a 76 mm diameter chain to be connected to hawsers for the tethering of oil tankers to single point moorings, FPSO and similar uses.

7.2.6.2 Approval of manufacturing.

7.2.6.2.1 The chafing chain shall be manufactured by works recognized by the Register in accordance with **7.2.1.3**.

7.2.6.3 Materials.

7.2.6.3.1 The materials used for the manufacture of the chafing chain shall meet the requirements of **7.2.2.2**.

7.2.6.4 Design, manufacturing, testing and certification.

7.2.6.4.1 The chafing chain shall be designed, manufactured, tested and certified in accordance with the requirements of **7.2.3**, **7.2.4** and **7.2.5**, except that batch heat treatment is permitted.

7.2.6.4.2 The arrangement of the end connections shall be of an approved type.

7.2.6.4.3 The common link shall be of the stud link type —Grade R3 or R4.

7.2.6.4.4 The chafing chain shall be capable of withstanding the breaking test loads of 4884 kN (Grade R3) and 6001 kN (Grade R4) (in this case, documented evidence of satisfactory testing of a similar diameter mooring chain in the prior 6 month period may be submitted to the Register for approval).

7.2.6.4.5 The chain lengths shall be proof load tested in accordance with **7.2.4.2**. The test load for Grade R3 is 3242 kN and for Grade R4 is 4731 kN.

7.2.6.4.6 The requirements specified in this Chapter are also applicable to other diameter chafing chains, such as 84 and 96 mm, subject to compliance with the proof and break load requirements specified for the chain grade and diameters in Table 7.2.3.2.7.1.

8 . REQUIREMENTS FOR MANUFACTURE OF ANCHORS

8.1 GENERAL

8.1.1 The present requirements apply to anchors and the materials used in their manufacture which are subject to technical supervision.

The Section requirements also apply to manufacture and testing, as well as to survey of:

anchors produced from cast or forged steel;

anchors fabricated by welded rolled steel plate and bars.

8.1.2 Anchors are divided into the following types:

.1 ordinary type: stockless anchors; stocked anchors;

.2 HHP anchors;

.3 SHHP anchors, not exceeding 1500 kg in mass.

Any changes to the anchor design made during the manufacture shall be preliminarily agreed with the Register.

8.1.3 The types of anchors:

8.1.3.1 Ordinary stockless anchors.

.1 ordinary stockless anchors shall be approved as a whole and shall have the design complying with the Register Rules;

.2 the mass of a stockless anchor box including the pins and fittings shall be not less than 60 % from the total mass of the anchor.

.3 for anchors of equal masses, the mass of each bower stockless anchor specified in Table 3.1.3-1, Part III "Equipment, Arrangements and Outfit" is required. The mass of individual anchors may vary within the range of ±7 % of the specified mass provided the total mass of the anchors is not less than the required mass of equal mass anchors.

8.1.3.2 HPP anchors.

.1 a high holding power (HPP) anchor is an anchor with twice the holding power of that of an ordinary stockless anchor of the same mass. An HPP anchor shall be suited for the use on the ship and shall not require any prior adjustment or particular placement on the sea bottom;

.2 if a special anchor type has a HPP anchor specification with proved high holding power and is used as a bower anchor, the mass of each separate anchor can be 75 % of the mass required for the ordinary stockless anchors in Table 3.1.3-1, Part III "Equipment, Arrangements and Outfit".

8.1.3.3 SHPP anchors.

.1 a super high holding power (SHPP) anchor is an anchor with four times the holding power of an ordinary stockless anchor of the same mass. An SHHP anchor is suited for use on the ships of limited area of navigation and does not require any prior adjustment or particular placement on the sea bottom.

.2 the use of SHHP is limited to the ships of limited area of navigation in accordance with **3.3.4**, Part III "Equipment, Arrangements and Outfit". The mass of an SHHP anchor, as a rule, does not exceed 1500 kg.

.3 the requirements to the design of SHHP anchors are applied if EN>205. In case of EN the SHHP anchor design criteria are applied to the mass of the anchor specified in IACS Rec No 10 for ordinary stockless anchors, lessened in accordance with 3.1.3, Part III "Equipment, Arrangements and Outfit" .

.4 when SHHP anchors with a confirmed holding power are used as bower anchors, the mass of each of these anchors may be decreased to 50 % of the mass of the ordinary stockless anchors according to Table 3.1.3-1, Part III "Equipment, Arrangements and Outfit".

.5 for the anchor to be recognized as an SHHP anchor satisfactory full-scale tests shall be carried out in accordance with the requirements of **8**, Appendix **3**, Section **3**, Part **4** "Technical Supervision during Manufacture of Products" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships, confirming that the anchor has a holding capacity of at least four times that of a conventional stockless anchor of the same mass or at least twice that of a recognized HHP anchor of the same mass.

8.1.4 Anchors and components thereof shall be made at the manufacturers recognized according to the requirements of **1.3**.

8.2 MATERIALS

8.2.1 Materials for anchors.

All anchors shall be manufactured from materials meeting the requirements given below.

8.2.1.1 Cast steel anchor flukes, shanks, swivels and shackles shall be manufactured and tested in accordance with the requirements of **3.8** for castings of welded structures.

The steel shall be fine grain treated with aluminium.

If test programme B is selected according to **8.4.2.1** then Charpy V notch (CVN) impact testing is required.

Special consideration shall be given to the use of materials for swivel castings.

8.2.1.2 Forged steel anchor pins, shanks, swivels and shackles shall be manufactured and tested in accordance with the requirements of **3.7**.

Shanks, swivels and shackles shall comply with the requirements for carbon and carbon-manganese steels for welded structures.

Materials for swivel castings may comply with the requirements of the standards agreed with the Register.

8.2.1.3 Rolled billets, plate and bar for fabricated steel anchors shall be manufactured and tested in accordance with the requirements of **3.2**.

8.2.1.4 Rolled bar intended for pins, swivels and shackles shall be manufactured and tested in accordance with the requirements of **3.2** or **3.7**.

8.2.2 In addition to the requirements of 8.2.1, the material of super high holding power anchors shall meet the following requirements:

welded steel anchors - **3.2** of this Part;

Section **4**, Part XIV "Welding";

cast steel anchors - **3.8** of this Part;

shackles - **3.7**, **3.8** of this Part.

The steel grade for welded anchors of high holding power shall be selected in accordance with the requirements of 1.2.1, Part II "Hull" for category II members. The level of requirements in impact tests of the welded joint shall meet the relevant requirements for a base metal (refer to Section 4, Part XIV "Welding"). The impact energy value required for the shackle material shall meet the requirements of **7.1** for Grade 3 steel (refer to Table 7.1.4.3.3).

The impact energy value (KV) for the material of anchor castings shall be not less than 27 J at 0°C.

8.3 MANUFACTURE OF ANCHORS

8.3.1 Tolerance.

If not otherwise specified in standards or on drawings and in specifications, the following tolerance shall be applied. The clearance either side of the shank within the shackle jaws shall be:

3 mm - for small anchors up to 3 t in weight;
4 mm - for anchors from 3 t to 5 t in weight;
6 mm - for anchors from 5 t to 7 t in weight;
12 mm - for anchors 7 t and over in weight.

The shackle pin shall be a push fit in the eyes of the shackle which shall be chamfered on the outside to ensure a good tightness when the pin is clenched over on fitting.

The shackle pin to hole tolerance shall be no more than 0,5 mm for pins up to 57 mm and 1,0 mm for pins of larger diameter.

The trunnion pin shall be a snug fit within the chamber and be long enough to prevent horizontal movement. The gap shall be no more than 1 % of the chamber length.

The lateral movement of the shank shall not exceed 3 deg (refer to Fig. 8.3.1).

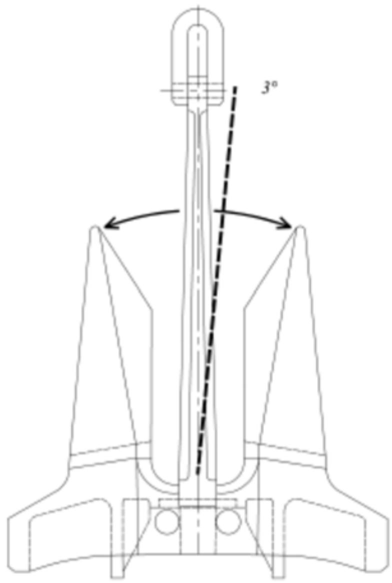


Fig.8.3.1

8.3.2 Welding of anchors.

Welded structures of fabricated anchors shall be done in accordance with procedures approved by the Register.

Welding shall be carried out by qualified welders holding a Certificate of Approval Test for Welder (refer to Section **5**, Part XIV "Welding").

Welding consumables shall be approved by the Register.

Non-destructive testing shall be carried out in accordance with the requirements of Section **3**, Part XIV "Welding".

8.3.3 Heat treatment.

Components for cast and forged anchors shall be properly heat treated; fully annealed; normalized or normalized and tempered in accordance with the requirements of **3.7** and **3.8**.

Fabricated anchors may require heat treatment for stress relief after welding.

The heat treatment for stress relief shall be carried out in accordance with the documentation approved by the Register. The temperature in heat treatment shall not exceed the tempering temperature for the base metal.

8.3.4 Non-destructive testing.

All parts of the anchor surface shall have a clean surface consisting with the method of anchor components manufacture.

No cracks, notches and other defects that would impair the anchor performance are acceptable.

8.3.5 Repairs.

Any necessary repairs to forged and cast anchors shall be carried out in accordance with the requirements of Sections **7** and **8**.

Repairs to fabricated anchors shall be agreed with the Register representative and carried out by qualified welders recognized by the Register.

Repair welding shall follow the same parameters and the same welding procedures used in construction.

8.3.6 Anchor assembly.

Assembly and fitting shall be done in accordance with the Register-approved documentation.

Securing of the anchor pin, shackle pin, etc. by welding shall be done in accordance with the documentation approved by the Register.

8.4 TESTING AND ISSUE OF DOCUMENTS

8.4.1 Proof load testing.

Proof load testing shall be carried out by an approved testing facility.

Proof load testing for ordinary, high holding power and super high holding power anchors shall be carried out in accordance with the pertinent requirements of Appendix 3 to Section 3, Part IV "Technical Supervision during Manufacture of Products" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

8.4.2 Product tests.

8.4.2.1 Product test programme.

Test for the material of each component product shall be carried out by one of the programmes below.

Table 8.4.2.1-1 **Applicable programmes for each product form**

Product tests	**Product form**		
	Cast products	Forged products	Welded products
Programme A	+	–	–
Programme B	+[1]	+	+
[1] 1 CVN impact tests shall be carried out to demonstrate at least 27 J average at 0°C.			

Table 8.4.2.1-2 **Product test type depending on test programme**

Programme A	**Programme B**
Drop test	–
Hammering test	–
Visual testing	Visual testing
Non-desrtuctive testing	Non-desrtuctive testing
–	Extended non-desrtuctive testing

8.4.2.2 Drop test.

Each anchor fluke and shank shall survive dropping from a height of 4 m on to a steel slab without fracturing.

The steel slab shall have an adequate thickness to resist the impact of the dropped component.

8.4.2.3 Hammering test.

After the drop test, hammering tests shall be carried out on each anchor fluke and shank, which is slung clear of the ground, using a non-metallic sling, and hammered to check the soundness of the component.

A hammer of at least 3 kg mass shall be used.

8.4.2.4 Visual testing. After proof load testing, visual testing of all accessible surfaces shall be carried out.

8.4.2.5 Non-desrtuctive testing. After proof load testing, non-desrtuctive testing shall be carried out in accordance with the requirements of Tables 8.4.2.5-1 and 8.4.2.5-2.

The scope and criteria of non-destructive testing for forgings and castings, which are equally applicable for anchor components, are given in **2.5**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

Table 8.4.2.5-1 **Non-desrtuctive testing for ordinary and high holding power anchors**

Location	Non-desrtuctive testing method
Gate locations	PT or MT
Riser locations	PT or MT
Weld repairs	PT or MT
Forged components	–
Fabrication welds	PT or MT
PT – penetrant testing MT– magnetic particle testing	

Table 8.4.2.5-2 **Non-desrtuctive testing for super high holding power anchors**

Location	Non-desrtuctive testing method
Gate locations	PT or MT and UT
Riser locations	PT or MT and UT
All surfaces of castings	PT or MT
Weld repairs	PT or MT
Forged components	–
Fabrication welds	PT or MT
PT – penetrant testing MT– magnetic particle testing UT– ultrasonic testing	

8.4.2.6 Extended non-desrtuctive testing.

After proof load testing and non-desrtuctive testing, extended non-desrtuctive testing shall be carried out in accordance with the requirements of Table 8.4.2.6.

Table 8.4.2.6 **Extended non-desrtuctive testing for ordinary, high holding power and super high holding power anchors**

Location	Non-desrtuctive testing method
Gate locations	PT or MT and UT
Riser locations	PT or MT and UT
All surfaces of castings	PT or MT
Random areas of castings	UT
Weld repairs	PT or MT
Forged components	–
Fabrication welds	PT or MT
PT – penetrant testing MT– magnetic particle testing UT– ultrasonic testing	

The scope and criteria of non-destructive testing for forgings and castings, which are equally applicable for anchor components, are given in **2.5**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

8.4.2.7 Repair criteria. If defects are detected by non-desrtuctive testing, repairs shall be carried out in accordance with **8.3.5**.

Fractures and other defects being the results of a drop test or hammering test repaires are not permitted and the component shall be rejected.

8.4.3 Mass and dimensional inspection.

Unless otherwise agreed, the verification of mass and dimensions is the responsibility of the manufacturer.

The Register's representative is only required to monitor this inspection.

The mass of the anchor shall exclude the mass of the swivel, unless this is an integral component.

8.4.4 Retests.

Retests shall be carried out in accordance with the requirements of **1.3.2.4**.

8.4.5 Marking.

Anchors which meet these requirements shall be stamped on the shank and the fluke.

The marking on the shank shall be approximately level with the fluke tips. On the fluke, these markings shall be approximately at a distance of two thirds from the tip of the bill to the center line of the crown on the right hand fluke looking from the crown towards the shank.

The markings shall include:

mass of anchor;

identification number (e.g. test report No. or Manufacturer's Certificate No.);

Register stamp;

manufacturer's mark.

The unique cast identification shall be cast on the shank and the fluke.

8.4.6 Documents to be issued to anchor.

The Register issues the certificate for anchors meeting the present requirements which shall contain the following data:

manufacturer's name;

anchor type;

anchor mass;

fluke and shank identification numbers;

grade of material;

proof test loads;

heat treatment;

Register stamp.

8.4.7 Painting.

Anchors shall not be painted until all tests and inspections have been completed.

9. TITANIUM ALLOYS

9.1 GENERAL

9.1.1 The requirements of this Chapter apply to the semi-finished products and products of titanium alloys to be surveyed by the Register during their manufacturing and in compliance with the requirements in the other chapters and parts of the Rules. These requirements cover the semi-finished products of wrought titanium alloys (sheets, plates, forgings, pressed sections) intended for deep-sea submersibles and civil shipbuilding. The Chapter also covers titanium alloy forgings intended for manufacture of the containment structures of nuclear power plants and pipes.

9.1.2 The alloys shall be designated in compliance with the national standards. In accordance with the requirements in **1.1.3**, use of the titanium alloys and their semi-finished products is allowed by international standards recognized by the Register, or according to the manufacturer's specifications agreed with the Register.

The application of semi-finished products of titanium alloys, whose chemical composition, mechanical properties or conditions of delivery do not comply with the requirements of the present Chapter, may be allowed after the submission of the data confirming the alloy properties, their corrosion resistance, both in general and in contact with other materials, welding procedure features and the alloys' behavior under the conditions of their use.

All semi-finished products of titanium alloys shall be manufactured under the Register technical supervision by the manufacturers recognized in accordance with **1.3.1.2**. The documentation for supplying the semi-finished products of titanium alloys shall be recognized by the Register. The material complying with the Register requirements (having the Manufacturer Certificate of Recognition in accordance with **1.3**) shall be delivered with the Register certificates and stamps.

9.1.3 The Register representative performing technical supervision at the manufacturer, which has no melting facilities, shall be provided with the certificates issued by the manufacturer of ingots, slabs or billets with the manufacturer's name, alloy grade, heat number and chemical composition specified. The particulars of the system, which allows identifying ingots, slabs or billets shall also be provided. The manufacturer producing titanium alloys shall be recognized by the Register.

9.2 WROUGHT TITANIUM ALLOYS

9.2.1 General.

These requirements apply to the semi-finished products of the following titanium alloys:

rolled products (sheet, plate) – alloys: ВТ1-00, ВТ1-0, ПТ-3В;

extruded sections (bulb-plate section) – alloy: ПТ-3В;

stamped billets – alloy: ПТ-3В;

forgings – alloys: ПТ-3В, 5В, 37;

rods – alloys: ВТ1-00, ВТ1-0, ВТ6, ВТ6С, ПТ-3В.

9.2.2 Chemical composition.

The chemical composition of wrought titanium alloys shall meet the requirements of Table 9.2.2. If required, on the Register’s demand, the samples for chemical analysis shall be taken directly from a semi-finished product (sheet, panel, forging, etc.).

Table 9.2.2 **Chemical composition of wrought titanium alloys**

Alloy grade	Basic components, %						Impurities, %, max						
	Al	V	Zr	Mo	Nb	C	Zr	Fe	Si	C	O_2	H_2	N_2
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
ВТ1-00	-	-	-	-	-	-	-	0,15	0,08	0,05	0,10	0,008	0,04
ВТ1-0	-	-	-	-	-	-	-	0,30	0,13	0,07	0,25	0,010	0,04

ПТ-3В	3,5-5,0	1,2-2,5	-	-	-	-	0,3	0,25	0,25	0,10	0,15	0,008	0,04
ВТ 6	5,3-6,8	3,5-5,3	-	-	-	-	0,3	0,60	0,10	0,10	0,20	0,015	0,05
ВТ 6С	5,3-6,5	3,5-4,5	-	-	-	-	0,3	0,25	0,15	0,10	0,15	0,015	0,05
5В	4,7-6,3	1,0-1,9	-	0,7-2,0	-	0,06-0,14	0,1	0,25	0,12	-	0,13	0,008	0,04
37	4,3-6,3	-	0,2-1,0	1,5-2,5	До 1,0	0,06-0,14	-	0,25	0,12	-	0,14	0,008	0,04

Notes: 1. The aluminum content of up to 0,3 % and 0,7 % in alloys ВТ1-00 and ВТ1-0, respectively, is allowed.

2. The content restrictions specified for forgings used in nuclear power plants:

N2< 0,03 % for alloys ПТ-3В and 5В;

Mo: 1,0 – 2,0 % for alloy 5В.

9.2.3 Mechanical properties.

The mechanical properties of wrought titanium alloys shall meet the requirements of Tables 9.2.3-1 ÷ 9.2.3-4.

Table 9.2.3-1 **Mechanical properties of sheets and plates**

Alloy	**Yield stress, $R_{p0,2}$, MPa, min**	**Tensile strength, R_m, MPa, min**	**Thickness, mm**	**Elongation, %, min, A_{5d},**
ВТ1-00	-	295	0,3 - 1,8	30
			1,8 - 6,0	25
			6,0 - 10,5	20
ВТ1-0	-	295	11 - 60	14
			60 - 150	10
ВТ1-0	-	375	0,3 - 1,8	25
			1,8 - 6,0	30
			1,8 - 6,0	25
			6,0 - 10,5	20
ВТ1-0	-	370	11 - 60	13
		295	60 - 150	10
ПТ-3В	588	638	0,3 - 145	10

Table 9.2.3-2 **Mechanical properties of extruded sections**

Alloy	**Yield stress, $R_{p0,2}$, MPa, min**	**Tensile strength, R_m, MPa, min**	**Section number**	**Elongation, %, min, A_{5d},**	**Impact toughness KCU, kJ/m^2**
ПТ-3В	588	638	6, 8, 10, 12	10	690

Table 9.2.3-3 **Mechanical properties of forgings and stamped billets**

Alloy	**Direction of cutting out specimens**	**Yield stress, $R_{p0,2}$, MPa, min**	**Tensile strength, R_m, MPa, min**	**Diameter or thickness (wall thickness), mm**	**Elongation, %, min, A5d,**	**Reduction of area, *Z*, %**	**Impact toughness KCU, kJ/m^2**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
ПТ-3В	Longitudinal	589	638	≤ 100	6-10	25	687
				> 100 to ≤ 200	9	25	25
				> 200 to ≤ 450	8	22	589

				> 450 to ≤ 650	7	-	-
	Tangential (transversal))	540	589	≤ 100	7	20	589
				> 100 to ≤ 200	7	15	
				> 200 to ≤ 450	6	15	
				> 450 to ≤ 650	5	13	
5B	Longitudinal	755	805	≤ 100	9	22	491
				> 100 to ≤ 650	8	18	
	Tangential			> 120 to ≤ 200	7	15	
				> 200 to ≤ 650	5	11	
37	Longitudinal	764	815	≤ 200	10	22	491
				> 200 to ≤ 650	7	17	
	Tangential	736	786	> 120 to ≤ 200	9	18	
				> 200 to ≤ 650	8	12	

Table 9.2.3-4 **Mechanical properties of rods**

Grade	**Yield stress, $R_{p0,2}$, MPa, min**	**Tensile strength, R_m, MPa, min**	**Elongation, %, min, A_{5d},**		**Impact toughness KCU, kJ/m²**
BT6	-	835 - 1049	140 - 250	6	-
BT6C	-	755 - 981	140 - 250	6	-
BT1-00	-	295	10 - 12	20	-
		295	12 - 100		100
		265	100 - 150		600
BT1-0	-	345	10 - 12	-	-
			12 - 100	15	700
			100 - 150	-	500
ПТ-3В	590	635-885	10 - 22	11	700
		635-855	25 - 150	-	-

Notes: 1. Billets for cutting out the specimens shall be annealed before machining.
2. BT6 and BT6C alloy rods shall be forged, BT1-00 – rolled, ПТ-3В – hot-rolled.
3. ПТ-3В alloy rods of over 25 mm in diameter shall be supplied in annealed condition.
4. Impact toughness on rods of 10 – 12 mm in diameter is not determined.

9.2.4 Condition of supply.

Condition of supply of titanium alloys shall be specified in the supply documentation approved by the Register.

The heat treatment (annealing) of semi-finished products of titanium and titanium alloy shall be carried out to improve the structure or relieve the stresses. The semi-finished products may be supplied without heat treatment or in an annealed condition.

The parameters of heat and heat and mechanical treatment providing alloy properties shall be specified by the manufacturer of semi-finished products. The condition of supply shall be indicated in the Manufacturer's Certificate issued to a semi-finished product.

Sheets and plates shall be supplied in annealed, pickled condition without a gas-saturated layer.

The latter shall be removed by pickling or abrasive cleaning of the entire surface followed by pickling. The absence of the gas-saturated layer shall be checked by sampling for a bend angle.

9.2.5 Sampling.

Sampling for determination of mechanical pro-perties of semi-finished products shall be provided in compliance with documentation approved by the Register.

Cutting out the billets for specimens, as well as making the very test specimens, shall be carried out by the methods, which prevent the changes of alloy properties due to hardening.

The sample dimensions shall be adequate for carrying out both single and repeated tests of longitudinal, transverse or tangential specimens. Samples and specimens shall be marked in such a way that they may be identified with a particular semi-finished product during testing, and the location of their cutting-out and orientation may be determined. The specimens shall be prepared according to**9.2.6.**

9.2.5.1 Unless otherwise specified, the samples for determination of mechanical properties shall be prepared in the way which secures the preparation of specimens with the longitudinal axis oriented as follows:

.1 rolled products:

specimens for tensile testing shall be cut out:

across rolling direction – sheets and plates of BT1-00 and BT1-0 titanium alloys of any thickness, and of the ПТ-3В of 0,3 – 8,0 mm thick;

along rolling direction – sheets and plates of ПТ-3В titanium alloy of 8,0 – 145 mm thick.

Impact test specimens for determination of impact toughness shall be cut out along rolling direction.

When preparing the specimens, the surface layer of metal shall be removed;

.2 forgings and stamped products of ПТ-3В alloy:

samples shall be taken in longitudinal direction coinciding with the longitudinal axis of a forging, in the tangential direction normal to the longitudinal axis and the radius of a forging, and in the transversal direction normal to the longitudinal axis for the forgings of a square and rectangular cross-section.

Tensile test specimens shall be cut out from the largest cross-section of the forgings:

from solid forgings – at a distance of 1/3 of the radius from a rough surface;

from hollow forgings with a wall thickness of up to 100 mm – at a distance of 1/2 of the forging wall thickness;

from hollow forgings with a wall thickness of over 100 mm – at a distance of 1/3 of the forging wall thickness from an outer surface;

from disc-shaped forgings – at a distance of up to 120 mm from the outer side surface of a forging.

Impact test specimens shall be cut out at a distance from a rough surface not exceeding one-sided machining allowance.

Impact test specimens and specimens for determination of the fraction of a total mass of hydrogen shall be taken at a distance from a rough surface not exceeding one-sided machining allowance;

.3 pressed section:

for tensile testing, billets shall be cut out from a section web, for impact testing and angle-set bend testing for a technological probe, the billets for making specimens shall be taken from a section flange;;

.4 rods:

specimens shall be cut out only along the rolling direction:

for rods of up to 35 mm in diameter – from the cross-section center;

for rods of over 35 mm in diameter – at a distance of 1/2 of a radius from the surface.

Mechanical properties of 5 % of rods, but at least one rod from the batch supplied, shall be checked.

Such check shall be carried out for two break and two impact test specimens.

9.2.6. Scope of tests.

9.2.6.1. Tests shall be conducted in compliance with the requirements of the national and/or international standards and Section **2**.

Unless otherwise specified, the tensile tests shall be conducted on the specimens of a rectangular cross-section with a gauge length $L_0 = 5{,}65\sqrt{S_0}$ and of a circular cross-section with a gauge length $L_0 = 5d_0$, and the impact tests for determination of the impact toughness KCU shall be conducted on the U-notched specimens according to **2.2.3.1.**

9.2.6.2 Semi-finished products of wrought titanium alloys shall be subjected for testing in batches.

The batch shall contain the semi-finished products of one grade (one heat), one shape and of the same dimensions (one thickness for sheets and plates), one condition of supply, manufactured according to the common process.

The batch size and the scope of metal testing shall comply with the requirements of documentation for delivery agreed by the Register. The batch size shall not exceed 8000 kg.

9.2.6.3. In general, unless otherwise specified, depending on the type of a semi-finished product, the scope of tests shall be as follows:

.1 rolled products:

mechanical properties of ВТ1-00, ВТ1-0 and ПТ-3В alloys shall be determined on each sheet and plate;

.2 forgings, stampings:

ПТ-3В, 5В and 37 alloys.

The mechanical properties on the forgings with a cross-section dimensioned 100 mm and less and/or with a mass of 30 kg or less shall be determined on 15 % of products in a batch, and on each forging (stamped product) for the ones with a cross-section dimensioned over 100 mm and/or with a mass of over 30 kg.

Every forging of ПТ-3В, 5В and 37 alloys shall be subjected to tensile testing, impact testing and checking the fraction of a total mass of hydrogen. Two specimens are generally cut out from one selected sample for tensile testing at temperatures 20°C and 350°C. Impact toughness is checked during impact test of two specimens at a temperature of 20°C.

As for forgings of 3000 mm long and over, the above tests (determination of mechanical properties and the fraction of a total mass of hydrogen) shall be carried out on the metal sampled from both ends of the forging.

The fraction of a total mass of hydrogen shall be checked with the manufacturer's normative documentation;

.3 pressed sections:

mechanical properties of the finished sections shall be determined on at least 10 % of a batch size, but on two sections as a minimum. Every section of the batch shall be checked for the geometrical dimensions, surface quality, twisting angle, angular dimensions and longitudinal curvature. The macrostructure shall be checked on a transverse macrotemplate cut out from the head end of each section;

.4 rods:

ВТ1-00, ВТ1, ВТ6, ВТ6С alloys. The determination of mechanical properties of finished sections and examination of their macrostructure and microstructure shall be carried out on at least 5 % of products from a batch.

Where the test results are unsatisfactory, retesting shall be carried out in compliance with the requirements in 1.3.2.3 and/or the documentation approved by the Register.

The macrostructure and microstructure of rods shall be examined on 5 % of products from the batch, but at least on one rod.

9.2.7 Inspection.

The semi-finished products of wrought titanium alloys prepared for delivery shall be free of internal and external defects, which adversely affect their use for their designated purpose.

Every semi-finished product shall be visually examined and its dimensions and surface condition shall be checked.

The nondestructive testing shall be used on the customer's demand in accordance with the documentation approved by the Register. The manufacturer is supposed to use the methods of non-destructive testing required in manufacture of the wrought titanium alloys in order to maintain the products quality at the level of the relevant standards.

To eliminate the detected surface defects, grinding or dressing may be used, provided that the semifinished product dimensions therewith will remain within tolerable deviations.

The manufacturer is liable for the quality of control and the maintenance of the specified dimensions of semi-finished products of titanium alloys.

The Register's representative may require to witness measurements of semi-finished products.

The minus thickness deviations for rolled products of titanium alloys of 10,2 mm thickness shall meet the documentation approved by the Register. Limiting deviations of the rolled products over 10,2 mm thick shall correspond to the values given in Tables 9.2.7-1 i 9.2.7-2.

Table 9.2.7-1 **Limiting minus thickness deviations for rolled products of titanium alloys depending on their thickness**

Grade	**Limiting minus deviations in thickness of plates, mm, at width, mm**		
ВТ1-00 ВТ1-0 ПТ-3В	thickness, mm	600, 700, 800, 900, 1000	1200, 1300, 1400, 1500, 1600
	11, 12, 13, 14, 15, 16	1,0	1,2
	18, 20, 22, 25, 28, 30, 32, 35	1,5	1,5
	38, 40, 45, 50, 55, 60	2,0	2,0

	70, 80, 90, 100	2,5	2,5
	110, 120, 130, 140, 150	3,0	3,0
ПТ-3В	from 12 to 16	1,2	1,2
	from 16 to 20	1,5	1,5
	from 20 to 35	1,5	1,5
	from 35 to 50	2,0	2,0

Table 9.2.7-2 **Limiting minus deviations in diameter for rods of titanium alloys**

Grade	**Nominal diameter, mm**	**Limiting deviation in diameter, mm**
ВТ1-00 ВТ1-0	10, 12	0,6
	14, 16, 18	0,8
	20, 22, 25, 28, 30, 32, 35, 38, 40, 42, 45, 48	1,0
	50, 52, 55, 60	1,4
	65, 70, 75, 80, 85, 90, 100	1,5
	110, 120, 130, 140, 150	3,0
ПТ-3В	10, 12	0,6
	14, 16, 18	0,8
	20	1,0
	35, 40, 45, 50, 55, 60	2,0
	65, 70, 75, 80, 90, 100, 110, 120, 130, 140, 150	3,0

9.2.8 Marking.

The basic requirements for marking are set forth in **1.4** and in the conditions of supply. Every semi-finished product shall have the manufacturer's marking and the Register stamp clearly made in the specified manner and in a due place.

The marking shall include, as a minimum:

name or designation of the manufacturer;

grade of alloy and condition of supply in compliance with the requirements of this Chapter;

number of a batch, semi-finished product or identification number according to the manufacturer's system, which allows tracing complete production process;

quality stamp.

If the semi-finished products are delivered in bundles, the marking may be made on tags.

9.2.9 Documents.

If supply is provided by piece, every batch or semi-finished product, which has undergone testing according to **9.2.6**, shall be provided with the Register Certificate and Manufacturer's Certificate. Form and content of the Manufacturer's Certificate shall be agreed with the Register and the customer.

The Register Certificate shall include:

order number;

construction project number, if known;

name, number, dimensions and weight of a semi-finished product;

grade (category) of alloy and condition of supply;

number of a batch or a semi-finished product, or identification number, which allows identifying the supplied material and tracing the whole production process;

name of manufacturer;

code and designation of drawing; designation of documentation the material supply complies with.

The Register Certificate shall be supplemented with the Manufacturer's Certificates containing the details of the chemical analysis and mechanical properties, which confirm the material conformity to the Register requirements, test reports.

9.3 TITANIUM ALLOYS FOR NUCLEAR POWER PLANTS

9.3.1. General requirements.

9.3.1.1. These requirements apply to forgings of titanium alloys intended for manufacturing of the containment structures of nuclear power plants being subject to the Register survey.

The forgings are manufactured of the following sizes:

solid round forgings of 80 to 650 mm in diameter and of 500 to 6000 mm in length;

circular forgings of 150 m to 3200 mm in outer diameter, 100 to 2900 mm in inner diameter and 50 to 1400 mm in length;

discs of 100 to 1800 mm in diameter and 50 to 800 mm in height;

expanded rings of 300 to 1800 mm in outer diameter, 40 to 450 mm in height and 30 to 120 mm in wall thickness.

9.3.1.2 As initial billets for manufacture of forgings the following shall be used:

ingots;

forgings and forged rods;

expanded rings.

9.3.1.3 The degree of plastic deformation (forging reduction) calculated on the basis of the cross section of a casting shall be such that freedom from defects, homogeneous structure and the required mechanical properties after heat treatment are provided.

9.3.2 Chemical composition.

The chemical composition of forgings of ПТ-3В and 5В titanium alloys for the structures of nuclear power plant (drum, cover and bottom) shall meet the requirements in Table 9.2.2.

The chemical composition of forgings (except the hydrogen content) is determined by a manufacturing process during melting ingots on the sample taken during its casting. The hydrogen content is determined during acceptance tests on the process samples cut out from the forgings.

9.3.3 Mechanical properties.

The minimum required values of strength (R_m and $R_{p0,2}$) and plastic (A_5 and Z) properties of the forging material depending on the cross-section size and the working temperature are given in Tables 9.3.3-1 and 9.3.3-2.

Table 9.3.3-1 **Mechanical properties of forgings of ПТ-3В alloy depending on working temperature and cross-section size**

Diameter or wall thickness, mm	**Characteristic**	**Test temperature, ^{0}C**							
		20	50	100	150	200	250	300	350
100-200	R_m, MPa	640	598	536	467	408	392	377	345
	$R_{p0,2}$, MPa	590	540	471	417	353	324	305	295
	A_5, %	9,0	9,2	9,5	11,5	13,5	14,4	15,3	14,6
	Z, %	22	22	23,3	28,2	33,0	35,2	37,4	36,5
201 – 450	R_m, MPa	640	598	536	472	408	392	377	345
	$R_{p0,2}$, MPa	590	540	471	412	353	324	305	295
	A_5, %	8,0	8,2	8,5	8,5	8,5	8,5	8,5	8,5
	Z, %	22	22,6	23,3	28,2	33	35,2	37,4	36,4

Table 9.3.3-2 **Mechanical properties of forgings of 5В alloy depending on working temperature and cross-section size**

Temperature, ^{0}C	**Forgings (cross-section of up to 100 mm)**				**Forgings (cross-section of 100 – 500 mm)**			
	R_m, MPa	$R_{p0,2}$, MPa	A_5, %	Z, %	R_m, MPa	$R_{p0,2}$, MPa	A_5, %	Z, %
20	780	730	9,0	18	755	687	7	15
150	620	560	9,0	20	600	540	8	20
250	530	460	10	20	500	440	8	20
350	450	390	12	25	420	370	8	20

Heat treatment shall be carried out in electric furnaces fitted with the recorders. The furnace shall provide the required process quality and the relevant level of monitoring, irrespective of the billet dimensions.

9.3.4 Condition of supply.

The general requirements for the condition of supply shall be in compliance with **9.2.4**.

9.3.5 Sampling.

Sampling shall be carried out in compliance with **9.2.5**.

9.3.6 Scope of tests.

Scope of forging tests shall comply with **9.2.6**.

9.3.7 Inspection.

9.3.7.1 The inspection of forgings shall be carried out in compliance with **9.2.7**.

9.3.7.2 Forgings shall be submitted to the Register for visual control of the quality of outer and inner surfaces (for circular forgings). Forgings shall be free of defects preventing their intended use.

9.3.7.3 Where the defects unacceptable by the Register Rules or the Register-approved documentation are detected during subsequent machining or testing, a forging shall be rejected, despite the covering documents and Manufacturer's Certificates available.

9.3.7.4 Surface defects may be eliminated by local dressing or removing the defective area metal with a boring cutter within the tolerances for machining. Non-destructive (dye penetrant, ultrasonic and radiographic) testing shall be used to check the absence of defects.

9.3.7.5 Forging repair with welding, as well as repair procedure, the subsequent heat treatment, the methods and criteria of inspection shall be agreed with the Register.

9.3.8 Marking.

The marking of forgings shall comply with **9.2.8**.

9.3.9 Documents.

The requirements for support documentation for forgings shall comply with **9.2.9**.

9.4 PIPES

9.4.1 General requirements.

9.4.1.1 These requirements apply to titanium hot-formed and cold-formed pipes, and also welded pipes for heat exchangers, steam generators, ship's systems and pipelines subject to the Register survey during manufacture.

9.4.1.2 Titanium pipes shall be produced by the manufacturers recognized according to **1.3.1.2** in compliance with these requirements and the requirements of the Register-approved standards and/or technical documentation.

9.4.2 Chemical composition.

9.4.2.1 The material chemical composition for titanium alloy pipes shall be selected considering the required mechanical properties at the room temperature and the design elevated one; the hydrogen content therewith shall not exceed:

for cold-formed pipes – 0,007 %;

for hot-formed pipes – 0,005 %;

for welded pipes – 0,007 %.

9.4.2.2. The chemical composition of the titanium pipe material, except the hydrogen content (hydrogen and nitrogen content for welded pipes), shall be determined by the relevant chemical composition of an ingot or tubular billet used for the pipe batch manufacture. Requirements to chemical composition of a titanium alloy ingot or tubular billets shall meet the requirements of Table 9.4.2.2 and be in accordance with the register approved documentation.

Table 9.4.2.2 **Chemical composition of titanium alloy ingots or tubular billets**

Alloy grade	**Chemical composition, %**													
	Impurities content, %, max													
	Ti	Al	V	Mo	Zr	Mn	Cr	Si	Fe	O_2	H_2	N	C	∑ Other impurities in total
ВТ1-00	Осно-ва	0,30	-	-	-	-	-	0,08	0,15	0,1	0,008	0,04	0,05	0,10
ВТ1-0		0,70	-	-	-	-	-	0,10	0,25	0,2	0,010	0,04	0,07	0,30
ПТ-1М		0,2÷ 0,7	-	-	0,3	-	-	0,10	0,2	0,12	0,006	0,04	0,07	0,30
ПТ-7М		1,8÷ 2,5	-	-	2÷3	-	-	≤0,12	≤0,25	≤0,15	≤0,006	≤0,04	≤ 0,1	≤ 0,30
ПТ-3В		3,5÷ 5,0	1,2÷ 2,5	-	≤0,12	-	-	≤0,12	≤0,25	≤0,15	≤0,006	≤0,04	≤ 0,1	≤ 0,30

9.4.3 Mechanical and technological properties.

9.4.3.1 Titanium alloys for ship's piping systems are classed by a strength level as follows:

ВТ1-00 and ВТ1-0 – yield stress ≥ 300 MPa;

ПТ-1М – yield stress ≥ 400 MPa;

ПТ-7М – yield stress ≥ 500 MPa;

ПТ-3В – yield stress ≥ 600 MPa.

The mechanical properties of pipes of titanium alloys shall meet the requirements of the Registerapproved standards and/or technical documentation.

9.4.3.2 Pipes shall be subjected to the following tests during manufacture: tensile test according to **2.2.2** (with determination of tensile strength, yield stress and elongation);

tensile test at elevated temperature (with determination of tensile strength and yield stress);

flattening test according to **2.2.5.2**;

drift expanding test (except hot-formed and finned pipes);

toughness test (for hot-formed pipes) according to **2.2.3.1**;

determination of hydrogen content by the manufacturer's normative documentation

determination of nitrogen content (for welded pipes) by the manufacturer's normative documentation;

ultrasonic testing for defects by the manufacturer's normative documentation.

9.4.3.3 Mechanical properties.

The mechanical properties of pipes are given in Tables 9.4.3.3-1 to 9.4.3.3-3.

Table 9.4.3.3-1 **Mechanical properties of cold-formed pipes of titanium alloys**

Alloy grade	**Tensile strength, R_m, MPa**	**Proof stress, $R_{p0,2}$, MPa**	**Elongation, A_5, %**	**Tensile strength, R_m, MPa**	**Proof stress, $R_{p0,2}$, MPa**	**Tensile strength, R_m, MPa**	**Proof stress, $R_{p0,2}$, MPa**
	min.						
	at temperature of 20°C			at temperature of 150°C		at temperature of 350°C	
ВТ1-0	353 - 569	245	24	216	147	-	-
ПТ-1М	353 - 569	216	27	225	157	-	-
ПТ-7М	480 - 667	382	20			245	176

Table 9.4.3.3-2 **Mechanical properties of hot-formed pipes of titanium alloys**

Alloy grade	**Tensile strength, R_m, MPa**	**Proof stress, $R_{p0,2}$, MPa**	**Elongation, A_5, %**	**Reduction in area, Z, %**	**Impact toughness KCU, kJ/m^2**	**Tensile strength, R_m, MPa**	**Proof stress, $R_{p0,2}$, MPa**	**Tensile strength, R_m, MPa**	**Proof stress, $R_{p0,2}$, MPa**
	min.								
	at temperature of 20°C					at temperature of 150°C		at temperature of 350°C	
ПТ-1М	343 – 539	245	24	45	784	215	147		
ПТ-7М	470 - 666	372	18	36	784			235	176
ПТ-3В	686 - 863	588	10	30	637			343	294

Table 9.4.3.3-3 **Mechanical properties of cold-formed (finned and small-diameter) pipes of titanium alloys**

Alloy grade	**Tensile strength, R_m, MPa**	**Proof stress, $R_{p0,2}$, MPa**	**Elongation, A_5, %**	**Tensile strength, R_m, MPa**	**Proof stress, $R_{p0,2}$, MPa**
		min.			
	at temperature of 20°C			at temperature of 350°C	
ВТ1-00	294 - 490	-	30	-	-
ПТ-7М	480 - 667	373	20	235	176

9.4.4. Condition of supply.

Pipes shall be supplied annealed and without heat treatment. The condition of supply shall be indicated in the Manufacturer's Certificate of Quality. The condition of supply is specified by the Register-approved and recognized standards, and/or the Register-approved technical documentation.

The type and conditions of heat treatment are specified by the pipes manufacturer.

9.4.5 Sampling.

he samples for making test specimens shall be taken from the ends of pipes. Where the test shall be executed on two specimens, the samples shall be taken from both ends.

9.4.6 Number of tests.

Titanium pipes shall be tested in batches. The batch shall comprise the pipes of one alloy grade, the same dimensions, heat and thermal treatment.

The number of pipes in the batch shall be the following:

300 pieces for cold-formed pipes,

75 pieces for hot-formed pipes.

The tests shall be carried out on at least 5 % of pipes in the batch, but not less than on two pipes.

From each pipe prepared for testing shall be taken:

one specimen from either end of the pipe: for determining the fraction of a total mass of hydrogen;

one specimen from either end of the pipe: for tensile test at room temperature;

one specimen from each end of the pipe: for tensile test at elevated temperature;

one specimen from each end of the pipe: for flattening;

one specimen from either end of the cold-formed pipe: for flaring.

Every pipe in the batch shall be subjected to ultrasonic testing for defects. All pipes shall be tested by hydraulic pressure.

The test pressure is specified by the standards for pipes or the Register-approved documentation.

The hydraulic tests may be omitted, if each pipe is subjected to ultrasonic or another equivalent testing.

9.4.7 Inspection.

Every pipe is subject to visual examination.

The pipe surface shall be free of any oil and dirt traces, cracks, scores, skins, deep dents, scale residue, laps, pickling rash, and deep lines.

The defects like fine lines, scratches, roughness, dents are acceptable if their depth is within the minus deviations for a wall thickness.

9.4.8 Marking and documents.

Identification, marking and issued documentation shall comply with **1.4.**

9.5 CAST TITANIUM ALLOYS

9.5.1 General.

The requirements of this Chapter apply to the parts and structures of cast titanium alloys used in hull and ship machinery structures subject to Register supervision.

9.5.2 Chemical composition and mechanical properties.

The chemical composition of cast titanium alloys shall meet the requirements in Table 9.5.2.

Table 9.5.2 **Chemical composition of cast titanium alloys**

Alloy grade	Basic components, %			Impurities, %, max							Other impurities in total, %
	Al	V	B	O_2	H_2	N_2	C	Fe	Si	V	
ТЛ3	3,0–4,5	-	0,0020 - 0,0060	0,15	0,008	0,04	0,15	0,25	0,12	0,15	0,50
ТЛ5	3,5–5,0	1,5–2,5	0,0020 - 0,0060	-	0,008	0,04	0,15	0,25	0,12	-	0,50

Notes: 1. The fraction of total vanadium mass in 3 alloy castings not subjected to oxidation may be up to 0,4 %.
2. Other impurities may include molybdenum, manganese, chromium, tin, zirconium, niobium, nickel and copper.
3. The boron (B) content other than the specified in the Table is acceptable if the requirements for mechanical properties are met.

9.5.3 Mechanical properties.

The mechanical properties of casting titanium alloys shall meet the requirements in Table 9.5.3.

Table 9.5.3 **Mechanical properties of cast titanium alloys**

Alloy grade	Tensile strength, R_m, MPa	Proof stress, $R_{p0,2}$, MPa	Elongation, A_5, %	Impact toughness, kJ/m^2	
				KCU	*KCV*
ТЛ3	440	490	10	688	392
ТЛ5	590	640	8	490	294

Possibility of using alloys with the other chemical composition and mechanical properties than those specified in Tables 9.5.2 and 9.5.3, shall be determined in accordance with **9.1.2**.

9.5.4 Condition of supply.

The requirements for condition of supply shall comply with 9.2.4.

9.5.5 Sampling.

The samples for determination of chemical composition and mechanical properties may be cast to the casting or cast separately. The sample size shall be equal or exceed the least one of the casting crosssections available. The sample locations and their number shall be specified by the manufacturer and agreed with the Register.

9.5.6 Requirements for casting surface.

Titanium alloy castings, depending on their purpose and operational conditions, are divided into five groups. The required group shall be indicated in the order. If that is lacking, the requirements for surface shall be agreed between a customer and manufacturer.

When the ceramic forms of fireproof oxides are used for manufacture of titanium alloy castings, a hardened layer is formed on their surface. The depth of such layer depends on the wall thickness and mass of the casting. The layer shall be removed:

for I to III group castings – during cleaning their surface with shot-blasting;

for IV and V group castings – by machining or any other way.

The hardened layer shall be removed from the surface of the casting of any group in way of welding, welding-on, built-up welding or welding-in.

The castings of all the groups shall be chipped and cleaned of molding sand mixture remains, and risers, gates, test strips and flashes shall be removed.

9.5.7 Scope of tests and control methods.

The list of checking operations and of the types of tests is established depending on the casting group, the requirements of a drawing and is specified according to Table 9.5.7.

Table 9.5.7

Types of mandatory tests and inspection of castings	**Group of castings**				
	I	II	III	IV	V
External examination	+	+	+	+	+
Check of dimensions	+	+	+	+	+
Determination of chemical composition	+	+	+	+	+
Determination of mechanical properties	-	+	+	+	+
Dye penetrant testing	+	+	+	+	+
Radiographic testing	-	-	+	+	+

Every casting shall be subjected to external examination and dimensions checking.

The chemical composition and mechanical properties shall be determined for the alloy of every heat.

The content of the impurities of iron, silicon, molybdenum, manganese, chromium, copper, nickel, tin, zirconium, niobium is not determined, and secured by the castings manufacturer in compliance with the requirements in Table 9.5.2.

The parts of the casting of any group prepared for welding, welding-on or built-up welding, as well as all the parts prepared for eliminating all kinds of defects with welding shall be subjected to dye penetrant testing.

The following shall be subjected to radiographic testing:

parts of castings prepared for welding, welding-on and built-up welding;

casting areas being friction surfaces and sealing surfaces;

places of welding, welding-on and built-up welding, and also places of eliminating defects by welding;

areas of group II castings shown in a drawing, and all areas of group III, IV and V castings accessible for checking.

The additional tests of castings are carried out if the relevant instructions are given in the order and/or drawing.

9.5.8 Inspection.

The castings submitted for examination shall be cleaned and be free of gates, risers and burrs. They shall have no defects adversely affecting their intended use. The surface defects within the tolerances for dimensions may be acceptable or be eliminated by machining.

When eliminating the defects, which dimensions exceed the permissible values specified by normative documentation, the former shall be removed by welding. The procedure for welding titanium alloy castings shall be approved by the Register.

9.5.9 Marking and documentation.

9.5.9.1 The requirements for marking and the documentation issued for castings shall comply with **1.4**. The marking shall be made in places specified in a drawing and supplemented with the year of casting manufacture.

Test strips (samples for determination of chemical composition and mechanical properties) shall be marked before their separation from the casting.

9.6 STEEL-TITANIUM LAMINATED COMPOSITE MATERIAL

9.6.1 General requirements.

9.6.1.1 The present requirements apply to semi-finished products of steel-titanium laminated composite material (steel-titanium semi-finished products) intended for the ship machinery structures (condensers and heat exchangers) subject to the technical supervision by the Register in accordance with the requirements of other parts of the Rules.

9.6.1.2 Steel-titanium semi-finished products shall be manufactured in compliance with the documentation approved by the Register at the enterprises recognized by the Register based on the requirements given in **1.3** and under technical supervision by the Register.

The Register representative performing technical supervision at the manufacturer of steel-titanium semi-finished products with no metallurgical production of all the composite material components shall be provided with the Manufacturer's Certificates for basic materials and the Register Certificates for basic materials. The Register may also require data to confirm the possibility of using steel-titanium semifinished products during the service.

9.6.1.3 Steel-titanium semi-finished products may be manufactured by explosion welding, hot rolling or other manufacturing methods.

9.6.1.4 Steel-titanium semi-finished products shall be manufactured not using cold rolling as final operation to obtain the required thickness.

9.6.1.5 Hull structural steel, which complies with the requirements of **3.2**, or steel complying the national/international standards, the application of which is agreed with the Register (the standards are specified in the approved documentation), is generally used as the base metal (steel) layer of steel-titanium semi-finished products.

9.6.1.6 Rolled plate and strip products of wrought steel-titanium alloys in annealed condition, which comply with the requirements of **9.2**, are used as titanium layer of steel-titanium semi-finished products.

9.6.1.7 In general, rolled steel and titanium for steel-titanium semi-finished products shall be manufactured by the enterprises recognized in accordance with **1.3** and under technical supervision by the Register.

9.6.2 Chemical composition and mechanical properties.

9.6.2.1 The chemical composition and mechanical properties of basic materials as well as properties of steel-titanium semi-finished products shall comply with the documentation approved by the Register. The chemical composition and mechanical properties of base materials intended for manufacture of steeltitanium semi-finished product shall comply with the requirements of **3.2** or national/international standards (refer to **9.6.1.5**) and **9.2**.

9.6.2.2 Condition of supply.

9.6.2.2.1 Steel-titanium semi-finished products shall be supplied in the condition complying with the Register-approved documentation.

9.6.2.3 Scope of testing.

9.6.2.3.1 The scope of testing and sampling of basic materials, steel and titanium alloys for steeltitanium semi-finished products shall be in accordance with the requirements of **3.2** or national/ international standards (refer to **9.6.1.5**) and **9.2**, accordingly.

9.6.2.3.2 During the initial survey for recognition of steel-titanium semi-finished product manufacture by the Register according to 1.3, the scope of prototype testing shall be based on the program developed by the manufacturer of steel-titanium semi-finished product and approved by the Register. The control test program at manufacturer's recognition shall include the following tests:

pull-off and shear tests to determine adhesion of test specimen layers in composite titanium-steel material;

bend tests to determine plybond strength of test specimen layers in composite steel-titanium material;

microanalysis of metal in the layer interface zone of composite steel-titanium material.

Tests shall be carried out on a control batch. For each manufacturing process stated (the same basic material supplier, the same size, the same condition of supply), 2 semi-finished products of a batch shall be submitted for testing.

Each semi-finished product of the control batch shall be subject to visual and ultrasonic testing to determine layer discontinuity zone.

9.6.2.3.3 During manufacture, the scope of testing shall be determined on the basis of the material delivery documentation approved by the Register or the national/international standard recognized by the Register. Semi-finished products shall be submitted for testing in batches. A batch shall consist of semifinished products of the same condition of supply, the same size, manufactured by the same process and using basic materials received from the same supplier. In general, not less than 10 % of semi-finished products shall be taken.

From each semi-finished product submitted for testing, samples shall be taken for pull-off and shear tests to determine layer adhesion.

Each semi-finished product in the batch shall be subject to visual and ultrasonic testing to determine layer discontinuity zones.

9.6.2.3.4 Sampling and testing.

9.6.2.3.4.1 The samples shall be taken at a distance not less than 25 mm from the edge of the semifinished product, at the farthest possible location from the explosion initiation point.

9.6.2.3.4.2 Bend tests to determine plybond strength of test specimen layers in composite steeltitanium material.

Bend test of bimetallic specimens at an angle of 80° shall be performed for the qualitative assessment of steel and titanium layer plybond strength. No layer separation during bending shall be a performance criterion. Two test specimens shall be taken from a sample for bend test. One bend test shall be carried out with the specimen of the titanium layer on the tensioned side and the other one with the specimen of the titanium layer on the compressed side. The procedure for test specimens' preparation and test performance shall comply with the manufacturer's documentation approved by the Register, national and/ or international standards.

9.6.2.3.4.3 Pull-off and shear tests of steel-titanium semi-finished product layers.

9.6.2.3.4.3.1 Pull-off and shear tests of steel-titanium semi-finished product layers obtained by explosion welding.

The tests shall be carried out on one specimen of each type (pull-off and shear tests).

Pull-off and shear tests shall be carried out at the room temperature.

The procedures of pull-off and shear tests are similar to those for aluminium-steel semi-finished product (**5.3**).

Pull-off tests shall be carried out on specimens as shown in Fig. 5.3.2.3.4.3.2-1. Shear tests shall be carried out on specimens as shown in Fig. 5.3.2.3.4.3.2-2.

For all the specimens tested, the ultimate pull-off and shear strength shall comply with the documentation approved by the Register.

Where the ultimate pull-off or shear strength of a laminated composite material is below the specified minimum, two additional pull-off and shear tests specimens shall be tested.

Each new value shall not be less than the specified minimum value.

Where the ultimate pull-off or shear strength of a laminated composite material is below the specified minimum value but exceeds 70 % of the minimum value, two additional pull-off and shear test specimens taken from each end of the semi-finished product shall be tested.

Each new value shall not be less than the specified minimum value.

9.6.2.3.4.4 Visual and non-destructive testing.

9.6.2.3.4.4.1 Each steel-titanium semi-finished product shall be subject to 100 % visual testing and ultrasonic testing to determine layer discontinuity zones.

9.6.2.3.4.4.2 The layer adhesion quality shall be determined by ultrasonic testing based on approved assessment criteria.

9.6.2.3.4.4.3 Micro structural analysis of interface between titanium and steel layers of steel-titanium semi-finished products.

Manufacturer shall submit the photos of interface surface between the layers of composite material with x(10 ÷ 20) and x100 magnification. Microstructural analysis shall be made on the sections cutout of the samples for mechanical tests.

9.6.3 Inspection.

9.6.3.1 All steel-titanium semi-finished products shall undergo surface inspection. Absence of defects not permitted under delivery documentation approved by the Register shall be guaranteed by the manufacturer, with a relevant entry to be made in the Manufacturer's Certificate. The surface defects resulting from manufacturing procedure are permitted if their depth is within the negative deviations specified in the documentation.

It is allowed to rectify the detected surface defects by grinding or flogging, provided these corrections do not change the size of the semi-finished product out of the allowed tolerances. For steel-titanium semifinished products, repairing of surface defects of steel and titanium layers is not permitted.

9.6.4 Marking.

The basic requirements for marking are set forth in 1.4.

Every semi-finished product shall have manufacturer's marking and the Register stamp clearly made in the specified manner and in a due place.

The marking shall include, as a minimum:

name and/or designation of the manufacturer;

grades of titanium alloy and steel;

condition of supply;

number of a batch, semi-finished product or identification number according to manufacturer's system, which allows tracing complete production process.

If the semi-finished products are delivered in bundles, the marking may be made on tags.

9.6.5 Documents.

If supply is provided by piece, every batch of semi-finished product, which has undergone testing shall be provided with the Register certificate. The Register certificate shall include, as a minimum:

order number;

construction project number, if known;

name, number, dimensions and mass of a semi-finished product;

grades of titanium alloy and steel, standards for supply;

condition of supply;

number of a batch or a semi-finished product or identification number, which allows identifying the supplied material.

The Register certificate shall be compulsorily supplemented with the results of the chemical analysis and mechanical tests, which confirm the material conformity with the Register requirements (the supplement may be Manufacturer's Certificate and/or test reports).

9.6.6 Welding of semi-finished products of steel-titanium laminated composite material.

9.6.6.1 Welded joints of steel-titanium semi-finished products to steel and titanium hull structural members shall be made by separate welding of layers between similar materials using fillet, overlap or butt welds.

9.6.6.2 Welding processes shall be approved in accordance with Sections **2** and **4** (**2.13** and **4.10**), Part XIV "Welding".

10. MATERIALS USED FOR CARGO CONTAINMENT SYSTEMS OF GAS CARRIERS

10.1 GENERAL

10.1.1 These requirements apply to the metallic and non-metallic materials used for cargo-containment systems of gas carriers. In accordance with 1.1.4, all materials and products mentioned in this Section shall be manufactured at the enterprises recognized by the Register in accordance woth **1.3.1.2** and under the Register technical supervision. The materials and products shall comply with the technical documentation agreed with the Register.

Requirements for the selection and application of the materials and products are specified in the relevant parts of the Rules.

10.1.2 Identification, marking and issued documentation for materials shall comply with **1.4**.

10.2 METALLIC MATERIALS FOR CARGO CONTAINMENT SYSTEMS OF GAS CARRIERS

10.2.1 Corrosion-resistant (stainless) steel for cargo containment systems of gas carriers.

10.2.1.1 These requirements apply to the steel used for cargo containment systems of gas carriers. Chemical composition, mechanical properties, condition of supply, sampling, scope of sampling and test procedures for steel used shall comply with the technical documentation agreed with the Register. In general, corrosion-resistant steel shall comply with the requirements of **3.16.1.3, 3.16.1.5 and 3.16.1.9**.

Welding consumables and welding procedures are also subject to the Register approval and shall comply with the technical documentation agreed with the Register.

10.2.2 Ferronickel alloy (36 % Ni) for cargo containment system of gas carriers.

10.2.2.1 These requirements apply to the ferronickel alloy (36 % Ni) also called Invar, which is used for cargo containment systems of gas carriers. Chemical composition, mechanical properties, condition of supply, sampling, scope of sampling and test procedures for alloy used shall comply with the technical documentation agreed with the Register.

Welding consumables and welding procedures are also subject to the Register approval and shall comply with the technical documentation agreed with the Register.

10.2.3 1550, 1565ч, 5083 wrought aluminium alloys.

10.2.3.1 These requirements apply to 1550, 1565ч, 5083 wrought aluminium alloys to be used for cargo containment systems of gas carriers. Chemical composition, mechanical properties, condition of supply, sampling and scope of testing for the alloys used shall comply with the technical documentation agreed with the Register.

Welding consumables and welding procedures are also subject to the Register approval and shall comply with the technical documentation agreed with the Register.

10.3 PLYWOOD

10.3.1 General requirements.

10.3.1.1 These requirements apply to the plywood sheets used in thermal insulation panels and boxes of cargo tanks in gas carriers with membrane systems of cargo containment.

10.3.1.2 The plywood shall be manufactured, stored and supplied in compliance with the standards agreed for application with the Register and technical requirements of firms at the enterprises recognized by the Register in accordance woth **1.3.1.2**. The Register may require for surveys of the suppliers of basic materials for plywood manufacture to be carried out.

10.3.2 Properties.

10.3.2.1 As raw materials for plywood manufacture, birch timber shall be used.

The plywood sheets shall not warp in service.

For sealing and fastening elements of thermal insulation structures, application of plywood made of hard timbers (beech, ash etc.) is permitted if provided in the technological procedure used by the designer of the cargo tank insulation system.

10.3.2.2 Plywood physical and chemical properties and scope of testing shall comply with the requirements of the technical documentation agreed with the Register. Safe plywood performance shall be confirmed by the relevant national/international standards.

10.4 GLASS WOOL

10.4.1 General requirements.

10.4.1.1 These requirements apply to the materials used to fill in the joints between thermal insulation panels of cargo tanks in gas carriers.

10.4.2 Properties.

10.4.2.1 The material shall not change its properties when exposed to sea water, nitrogen and liquefied natural gas. The material shall not cause corrosion in contacting metallic surfaces. The maximum thermal conductivity coefficient shall not to exceed 0,35W/m·°C at 20°C. The physical and chemical properties of glass wool, scope of testing and laying-up procedure shall comply with the technical documentation agreed with the Register.

10.5 GLASS FIBRE USED IN GAS CARRIER MEMBRANES

10.5.1 General requirements.

10.5.1.1 These requirements apply to the materials used at the edges of membrane parts and beneath top bridge pads of the primary membrane.

10.5.2 Properties.

10.5.2.1 Glass fibre used in membranes shall be tested for compatibility with glue and adhesive compounds.

10.5.2.2 Physical and chemical properties of glass fibre and scope of testing shall comply with the technical documentation agreed with the Register.

10.6 RUBBER TECHNICAL GOODS

10.6.1 General requirements.

10.6.1.1 These requirements apply to the materials used for the thermal insulation of gas carrier membranes.

10.6.2 Reinforced polyurethane foam (R-PUF).

10.6.2.1 Reinforced polyurethane foam is used in thermal insulation panels.

10.6.2.1.1 Properties.

10.6.2.1.1.1 The material shall comply with the following requirements:

retain its properties at –163°C;

be chemically compatible with liquefied natural gas, sea water and nitrogen-ammonia mixture;

retain its properties under pressure variations due to cargo displacement;

retain its properties under pressure variations up to the absolute value of 200 mbar;

retain its properties during expected service life of the ship.

10.6.2.1.1.2 The physical and chemical properties of reinforced polyurethane and scope of testing shall comply with the technical documentation agreed with the Register.

10.6.3 Low-density foam (LDF).

10.6.3.1 Low-density foam (LDF) is used to fill in the spaces between corner panel components and holes in reinforced polyurethane panels.

10.6.3.1.1 Properties.

10.6.3.1.1.1 Low-density foam (LDF) shall be tested for compatibility with reinforced polyurethane foam, load bearing mastic and adhesion compounds:

shall retain its properties at –163°C;

shall be chemically compatible with liquefied natural gas, sea water and nitrogen-ammonia mixture.

10.6.3.1.1.2 The physical and chemical properties of low-density foam (LDF) and scope of testing shall comply with the technical documentation agreed with the Register.

10.7 PERLITE (VOLCANIC GLASS)

10.7.1 General requirements.

10.7.1.1 These requirements apply to the materials used for the manufacture of thermal insulation systems for cargo tanks of gas carriers.

Perlite is used as filler material in thermal insulation systems between membrane layers. Perlite shall be treated with water-repellent silicone.

10.7.1.2 The physical and chemical properties of perlite and scope of testing shall comply with the technical documentation agreed with the Register.

10.8 ANTI-STICKING FILM.

10.8.1 General requirements.

10.8.1.1 These requirements apply to the material between the inner hull and load bearing mastic in the systems where Invar membranes are used.

This film is a flexible material used to prevent the load bearing mastic sticking to the gas carrier hull. It is recommended that non-combustible kraft paper with a specific weight of 0,07 kg/m^2 be used as the film.

The physical and chemical properties and scope of testing shall comply with the technical documentation agreed with the Register.

10.9 MASTICS, ADHESIVES, PAINT COATINGS

10.9.1 Load bearing mastic.

10.9.1.1 General requirements.

10.9.1.1.1 The mastic in the form of straps shall be applied to the plywood surface of the thermal insulation panel and serves as an additional fixation of the secondary thermal insulation panel to the hull and as an aligner as well as an adhesive for plugs and for pressure propagation from the corner panels.

10.9.1.2 Properties.

10.9.1.2.1 Generally, the material is epoxy-based mastic consisting mainly of two components:

rubber (with or without a filler);

hardener (with or without a filler).

The material shall not warp under compression and shall be compatible with sea water.

10.9.1.2.2 The physical and chemical properties of the load bearing mastic and scope of testing shall comply with the technical documentation agreed with the Register..

10.9.1.3 For material supplied to the shipyard, operating instructions shall be provided containing the following:

storage conditions: temperature range and storage time;

mixing proportions with permissible deviations;

dependence of temperature range necessary to obtain the required properties on time;

dependence of mastic usability on climatic conditions;

dependence of mastic usability on compression time.

10.9.2 Insulation panel adhesive.

10.9.2.1 General requirements.

10.9.2.1.1 The material is used in membrane systems when manufacturing flat thermal insulation panels, corner panels, gluing hard cellular materials, gluing hard cellular materials to plywood and triplex as well as gluing triplex to plywood.

10.9.2.2 Properties.

10.9.2.2.1 The material is a mixture of rubber and hardener and may contain particular fillers. The material shall be compatible with sea water, gaseous methane and nitrogen-ammonia mixture. Durability shall be at least 40 years.

10.9.2.2.2 The physical and chemical properties of the adhesive and scope of testing shall comply with the technical documentation agreed with the Register.

10.9.2.3 For material supplied to the shipyard, operating instructions shall be provided containing the following:

storage conditions: temperature range and storage time;

mixing proportions with permissible deviations;

dependence of temperature range necessary to obtain the required properties on time;

dependence of mastic usability on climatic conditions;

dependence of mastic usability on compression time.

10.9.3 Secondary barrier adhesive.

10.9.3.1 General requirements.

10.9.3.1. The material is used in membrane systems when manufacturing flat thermal insulation panels, during intermediate thermal insulation box assembly and for gluing the flexible secondary barrier to the rigid one.

10.9.3.2 Properties.

10.9.3.2.1 The material is a mixture of rubber and hardener and may contain particular fillers. The material shall be compatible with sea water, gaseous methane and nitrogen-ammonia mixture.

10.9.3.2.2 The physical and chemical properties of the adhesive and scope of testing shall comply with the technical documentation agreed with the Register.

10.9.4 Inner hull protection coating.

10.9.4.1 General requirements.

10.9.4.1.1 The material is used for painting the inner surface of hull in way of cargo tanks equipped with membrane systems.

Insulation panels of these systems are fixed to the hull with load bearing mastic and studs.

To ensure better adhesion, the inner surface of hull shall be made free of rust and foreign particles, and painted.

The coating shall have the following properties:

be able to transfer a load between thermal insulation panels and inner hull;

be compatible with load bearing mastic (epoxy or polyurethane) and sea water;

allow stud welding to the coating;

in case of welding on the coating, not adversely affect the weld quality.

10.9.4.1.2 The physical and chemical properties of the material and scope of testing shall comply with the technical documentation agreed with the Register.

11. MATERIALS USED FOR SHIPS INTENDED FOR LONG-TERM OPERATION AT LOW TEMPERATURE

11.1 General requirements.

11.1.1 The requirements of this Chapter apply to ships intended for operation in low temperatures, with a distinguishing mark **WINTERIZATION (DAT)** in the class notation.

11.1.2 Materials used for hull structures and ship machinery items subject to the technical supervision of the Register in accordance with the relevant Parts of the Rules shall comply with the requirements of this Part and with the Register approved standards and/or with the Register agreed specifications.

11.1.3 Ice-resistant hull plating, structures, machinery and equipment shall meet the requirements of **6.5.3**.

11.2.1 Steel plates and sections for hull structural members, ship equipment and machinery intended for prolonged exposure to low service temperatures shall be selected toaccordance with **1.2.3** Part II "Hull" with due regard to the adopted value of design ambient temperature. Proceeding from the selected strength level and service conditions, the requirements for steel are specified in **3.2**, **3.5**, **3,13**, **3.14** and **3.17** of this Part.

In particular cases, at the request of the Register, steel for essential hull structures may be used upon receipt of data on crack resistance of the steel. The information received shall be assessed with regard to the requirements of Part XII "Materials" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms.

11.2.2 Steel for machinery and equipment foundations installed on the open decks, in open and enclosed unheated spaces shall comply with the requirements of **1.2.3.1**, Part II "Hull" (structural members of category I).

The design temperature of structure shall be assumed according to **1.2.3.4**, Part II "Hull".

11.2.3 The material of steel forgings and castings for the components of ship equipment, machinery and fittings installed on the open decks and in the open unheated spaces of ships shall comply with the requirements of 3.7 or 3.8 accordingly, or with the Register approved standards and/or Register agreed specifications.

The material shall be selected proceeding from the purpose of the forgings and castings, and with regard to their operating temperature and the requirements of **3.5**.

11.2.4 Grey iron and ductile cast iron of ferritic structure is not permitted for the manufacture of components of ship equipment, machinery and fittings installed on the open decks and in the open unheated spaces of ships with a distinguishing mark **WINTERIZATION (DAT)** in the class notation.

11.2.5 Plastics, gasket and seal materials, as well as materials of organic origin used for ship equipment, machinery and fittings and for systems installed on open the decks and in the open unheated spaces of ships shall comply with the applicable requirements of Section **6**, with the Register approved standards and/or with the Register agreed specifications. In addition, a documentary confirmation of the above materials reliability at design temperature or test reports issued by the laboratories recognized by the Register, another classification society (ACS) or authorized state authorities shall be submitted.

11.2.6 The use of anchor and mooring chain cables of category 1 is not permitted.

The material for anchor and mooring chain cables shall comply with the requirements of **3.6** and Section **7**, as well as with the Register approved standards and/or with the Register agreed specifications. The maximum impact test temperature is equal to - 20^{O}C.

The results of steel test at operating temperature shall be submitted to the Register.

PART XIV. WELDING

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of this Part of the Rules apply to the following items, which are subject to survey by the Register:

.1 ship hulls;

.2 machinery and machinery installations;

.3 steam boilers, heat exchangers and pressure vessels;

.4 piping;

.5 ship equipment and arrangements.

1.1.2 The requirements of this Part shall establish requirements for welding consumables manufacture, welding procedures, and testing of welded structures stated in **1.1.1**.

1.1.3 The requirements of this Part may be applied when carrying out repairs of structures stated in **1.1.1** as well, to an extent, which is deemed necessary and advisable.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations pertaining to the general terminology of the Rules shall be found in the General Regulations for the Classification and Other Activity and in Part I Classification and Construction of Sea-Going Ships[1].

Besides, for the purpose of this Part the following definitions and explanations have been adopted.

High temperature brazing (hard brazing) is a brazing method, at which the melting temperature of the solder is above 450°C.

Welding consumables include electrode, welding wire, flux and schielding gas used in welding.

Heat-af fected zone is the layer of the base metal adjacent to a weld (or to the deposited metal) where structural changes were caused by the welding heat.

Weld metal is the metal obtained by the merging of the fused base metal and the deposited metal, or by fusion of the base metal only.

Deposited metal is the metal obtained by melting of electrodes or welding wire and containing no appreciable admixture of the base metal.

Base metal is the metal of items being welded.

Penetration is the merging of the base metal into the deposited one or the merging of the fused metal of both the components being welded.

1.3 GENERAL

1.3.1 Welding of items stated in **1.1.1** shall be effected by certified welders (operators) and Register-approved welding works (shops, bays) using welding consumables and welding processes approved by the Register.

The application of each of the welding processes (or its variant) at a particular works shall be backed up by the results of testing conducted in accordance with a program agreed with the Register according to Section **6**, Part III "Technical Supervision during Manufacture of Materials" of Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships. Welding consumables shall be approved in compliance with the requirements of Section **4**.

1.3.2 Welding operation on structures subject to survey by the Register shall be performed by those welders only who stood the tests prescribed by Section **5**.

1.4 SCOPE OF SURVEYS

1.4.1 General provisions concerning survey during manufacture of materials and equipment shall be found in General Regulations for the Classification and Other Activity.

1.4.2 As far as structures stated in **1.1.1** are concerned, the following is subject to survey by the Register:

.1 welding consumables;

[1] Hereinafter - Part I «Classification».

.2 welding procedures (choosing of welding consumables, preparation of parts for welding assembly, pre- and postheating, heat treatment);

.3 methods and scope of non-destructive testing and criteria for evaluation of welded joints.

1.5 TECHNICAL DOCUMENTATION

1.5.1 The scope of technical documentation on welding, which shall be agreed as part of the ship design, is set out in Part I "Classification".

Technical documentation on items specified in **1.1.1** shall include information on welding required by those parts of the Rules, which cover the items concerned.

1.5.2 The composition of technical documentation for welding consumables being approved shall be determined proceeding from **4.1.2.1.**

2. TECHNOLOGICAL REQUIREMENTS FOR WELDING

2.1 GENERAL

2.1.1 The present technological requirements shall be applied when welding structures specified in **1.1.1**.

To effect welding operations and non-destructive testing of welded joints in structures subject to survey by the Register the works shall have adequate equipment.

2.1.2 Where welding is performed at low temperature, working conditions shall be provided to enable the welder to produce sound welds.

The welding site shall be protected from draught and precipitation.

2.1.3 As far as practicable, structures shall be welded in enclosed spaces heated in winter. Where outdoor works are required, measures shall be taken to protect the welding site from wind, moisture and cold.

In case of shielded metal arc welding, the possibility of gas protection fault due to wind and draughts shall be excluded. Generally, the air speed at the welding site shall not exceed 0,5 m/s to provide the stable shielded gas.

Shielded metal arc welding procedures providing sound welding at high air speed shall be approved by the Register.

When performing outdoor works under unfavourable weather conditions, the edges to be welded shall always be dried by heating.

2.1.4 Welding at ambient temperatures below zero.

2.1.4.1 Where structures are welded at ambient temperatures below zero, the appropriate measures shall be taken to ensure satisfactory quality of welds, among others,

testing and cleaning of the edges to be welded from snow, frost and ice;

drying by heating of the edges to be welded to 20°C, as a minimum;

local preheating of the edges to be welded prior to welding;

use of thermal insulation means;

use of the processes providing the required interrun temperature above zero during welding.

The specific measures to be taken when welding at ambient temperatures below zero shall be selected by the welded structures manufacturer and shall be agreed with the Register at approving the welding procedures.

2.1.4.2 On condition proper quality of welded joints is ensured, welding and all related operations on the structures subject to technical supervision by the Register made of hull structural steel of normal and higher strength 20 mm in thickness are generally permitted at ambient temperature up to –25°C.

For specific conditions, the minimum permissible ambient temperature for unheated welding shall be agreed with the Register at approving welding procedures.

In the following cases the edges of parts to be welded shall be preheated at least to 20°C over a width of 100 mm to both sides of the weld at ambient temperature:

up to – 25°C for higher strength steels where the parts of the weld are more than 20 mm in thickness;

below – 15°C for forgings and castings used for ship hull;

below –10°C for parts of joints made of semi-killed steel.

To be preheated is the side of the joint to be welded first. If during welding the ambient temperature drops below the minimum permissible value, the welding shall be stopped after filling in the groove on one side of the joint and making the back sealing run or the first run on the other side. Prior to welding renewal after the stop, reheating or redrying of the edges shall be performed, where necessary.

2.1.5 The welding of piping made of low alloy steel, piping of the steam main as well as piping, which shall operate at temperatures above 350°C, shall not be conducted at temperatures below zero.

2.1.6 The structural requirements for welds aimed at ensuring their strength shall be found in the relevant parts of the Rules.

2.1.7 The edge preparation of the parts to be welded shall be effected in conformity with standards or with drawings approved by the Register.

2.1.8 The edges of parts to be welded shall be prepared by methods, which ensure the required quality of welded joints in accordance with the requirements of the Rules.

2.1.9 From the edges of the parts to be welded, oil, moisture, scale, rust paint and other contaminating substances shall be removed. Steel parts coated with a primer may be welded without removing it; in this case the primer shall be of a type approved by the Register in accordance with **6.5.4.3**, Part XIII "Materials".

2.1.10 When structures are welded, the sequence of welding operations shall be such as to ensure the absence of excessive residual stresses or distortions.

2.1.11 When it is necessary to preheat the parts to be welded, the preheating temperature shall be determined taking into account chemical composition of metal, welding process, thickness of parts to be welded, level of weld stresses and conditions of heat transfer through the structure from the weld zone.

When complex structures are welded, the preheating temperatures shall be specified in the documentation submitted to the Register for approval.

2.1.12 Welding and cutting under water as well as welding operations on structures with water present on the reverse side during the welding process may be allowed by the technological instructions and/or the standards of the manufacturer, including the control methods approved by the Register.

2.1.13 When plates, sheets and the like shall be welded into a rigid contour, technological measures shall be taken to reduce the stresses caused by welding. An opening with closed perimeter is considered to have the rigid contour if any of its dimensions is less than 60 plate thicknesses in the considered spot.

For complex structures a contour may be regarded as rigid even at greater ratios of opening dimensions.

2.1.14 Dressing of welded structures is permitted within reasonable limits only. Hot dressing with mechanical effect and without one is permitted.

When doing this, no damage to the joint or plate surface is admissible. For hot dressing, the temperature shall not exceed 650°C, but in no case shall the heating involve changes in the metal structure.

2.1.15 Postweld heat treatment is required to eliminate residual stresses. The type of heat treatment shall be determined by the manufacturer proceeding from the properties of material, and it shall be agreed upon with the Register.

2.1.16 Welding of components made of cold-bent hull structural steel may be effected without any heat treatment if the inner radius of bending complies with standards.

In case no such standards are available the said radius shall be equal to at least the triple thickness of the plate.

2.1.17 Welding consumables with controllable hydrogen content in the deposited metal shall be stored and calcinated before use in compliance with the manufacturer's recommendations.

2.2 WELDING OF SHIP HULL AND EQUIPMENT

2.2.1 The parts shall be assembled in such a way that the stresses arising during assembly and welding are as low as possible.

Tack welding shall be performed only by persons possessing the necessary qualifications. Tack welding shall be carried out using welding consumables of the grades required for welding structural components. Tack welds shall be free from any defects, which could impair the quality of welded joints.

The tack welds shall be checked for absence of cracks or other defects. When cracks occur in way of tack welds, they shall be cut out to sound metal and rewelded. Temporary fittings used for assembly shall be kept to a minimum and be welded and tack-welded in conformity with the requirements stated above.

Excessive cutouts and other damage to the base metal that occurs while removing temporary fittings shall be rewelded and the rectified areas dressed to ensure gradual transition to the base metal. In doing so, the reduction of the base metal thickness shall not exceed the permissible tolerances for plate thickness specified in the standards.

Protruding remainders of welds used for the attachment of temporary fittings to the hull structure parts listed below shall be removed and then dressed (the permissible reinforcement shall not exceed the tolerances for butt weld reinforcement for the structures concerned):

.1 strength deck (plating and longitudinal framing members including continuous side coamings of cargo hatches);

.2 bottom (plating and longitudinal framing members);

.3 sides;

.4 sheerstrake and bilge strake (plating and longitudinal framing members);

.5 bulkheads forming boundaries of tanks;

.6 deep framing members in tanks;

.7 structures in areas of intensive vibration.

For other structures the necessity of dressing the welds after removal of temporary fittings shall be determined by the customer.

2.2.2 When butt joints are being assembled, mutual misalignment of plates up to 0,1 of their thickness but not over 3 mm is admissible.

2.2.3 Undercuts in excess of values stated in Table 3.3.2.1 may be rewelded or grounded.

2.2.4 Choice of welding consumables grades for welding of normal and higher strength steel structures.

Welding consumables shall be employed for welding those steel grades, for which they were permitted by the Register in accordance with Table 2.2.4. Besides the following requirements shall be followed:

.1 when joining normal to higher strength hull structural steel, welding consumables of the lowest acceptable grade, according to Table 2.2.4 and this paragraph, for either steel being joined may be used (for instance, for welded joint of Grades D and E32 steels, the welding consumables of Grade 2 may be used);

.2 when joining steels of the same strength level but with different requirements for impact test temperature, welding consumables of the lowest acceptable grade, according to Table 2.2.4, for either steel being joined may be used (for instance, for welded joint of Grades D32 and E32 steels, the welding consumables of Grade 2 may be used);

.3 when joining higher strength hull structural steel to the same or normal strength hull structural steel, controlled diffusible hydrogen type welding consumables, according to Table 4.2.3.4, shall be used.

Other welding consumables may be used only on the permission of the Register for steels having the carbon equivalent (refer to **3.2.2**, Part XIII "Materials") $C_{eq} \leq 41$ following tests according to the program approved by the Register;

.4 the welding consumables approved for steel Grades A40, D40, E40 and/or F40 may also be used for corresponding Grades A, B, D, E of normal steel strengths only on submission of positive tests results carried out according to the program approved by the Register;

.5 when joining higher strength steels using Grades 1YS, 1YT, 1YM, 1YTM, 1YV grade welding consumables, the material thickness shall not exceed 25 mm;

.6 the welding consumables in Table 2.2.4 may also be used for welding of steel other than that shown in the table if the mechanical properties and chemical composition of such a steel are equivalent to the same of the steel, for which the given welding consumable was approved;

.7 rutile electrodes shall not be used for welding the following joints:

mounting butt joints of ship sections;

all butts and seams of the ice belt of shell plating;

butt joints of longitudinal members;

butt joints of hull structure more than 20 mm thick;

solid structures (sternframe, stem, etc.), as well as butt joints to be welded in a rigid contour (a contour is considered rigid when the ratio of its minimal dimension to the plate thickness is less than 60);

.8 oxide-coated electrodes shall not be used for welding of structures regulated by Part II "Hull".

Table 2.2.4

Grade of welding consumables	Hull structural steel											
	normal strength				higher strength							
	A	B	D	E	A32, A36	D32, D36	E32, E36	F32, F36	A40	D40	E40	F40
1, 1S, 1T, 1M, 1TM, 1V	+	–	–	–	–	–	–	–	–	–	–	–
1YS, 1YT, 1YM, 1YTM, 1YV	+	–	–	–	+[1]	–	–	–	–	–	–	–
2, 2S, 2T, 2M, 2TM, 2V	+	+	+	–	–	–	–	–	–	–	–	–
2Y, 2YS, 2YT, 2YM, 2YTM, 2YV	+	+	+	–	+	+	–	–	–	–	–	–
2Y40, 2Y40S, 2Y40T, 2Y40M, 2Y40TM, 2Y40V	Refer to **2.2.4.4**				+	+	–	–	+	+	–	–
3, 3S, 3T, 3M, 3TM, 3V	+	+	+	+	–	–	–	–	–	–	–	–
3Y, 3YS, 3YT, 3YM, 3YTM, 3YV	+	+	+	+	+	+	+	–	–	–	–	–
3Y40, 3Y40S, 3Y40T, 3Y40M, 3Y40TM, 3Y40V	Refer to **2.2.4.4**				+	+	+	–	+	+	+	–
4Y, 4YS, 4YT, 4YM, 4YTM, 4YV	+	+	+	+	+	+	+	+	–	–	–	–

4Y40, 4Y40S, 4Y40T, 4Y40M, 4Y40TM, 4YV	Refer to **2.2.4.4**	+	+	+	+	+	+	+	+
5Y40, 5Y40S, 5Y40T, 5Y40M, 5Y40TM, 5Y40V	Refer to **2.2.4.4**	+	+	+	+	+	+	+	+
[1]Refer to **2.2.5**.									

2.2.5 Choice of welding consumables grades for welding of high strength steel structures.

Welding consumables shall be employed for welding those high strength steel grades, for which they were permitted by the Register according to Tables 2.2.5-1 and 2.2.5-2.

Table 2.2.5-1

Identification of welding consumables grades by test temperature	Identification of high strength steel grades by impact test temperature			
	A(420/960)	D(420/960)	E(420/960)	F(420/690)
3Y (42/96)	+	+	–	–
4Y (42/96)	+	+	+	–
5Y (42/69)	+	+	+	+

Table 2.2.5-2

Identification of welding consumables grades by strength level	Identification of high strength steel grades by strength level							
	(A/F)420	(A/F)460	(A/F)500	(A/F)550	(A/F)620	(A/F)690	(A/F)890	(A/F)960
(3Y/5Y) 42	+	–	–	–	–	–	–	–
(3Y/5Y) 46	+	+	–	–	–	–	–	–
(3Y/5Y) 50	+	+	+	–	–	–	–	–
(3Y/5Y) 55	–	–	+	+	–	–	–	–
(3Y/5Y) 62	–	–	–	+	+	–	–	–
(3Y/5Y) 69	–	–	–	–	+	+	–	–
(3Y/5Y) 89	–	–	–	–	–	–	+	–
(3Y/5Y) 96	–	–	–	–	–	–	+	+

Besides, the following restrictions and requirements shall be followed:

.1 the scope of application of the particular welding consumable grade may be limited, based on the test results, to one base metal grade and not be extended to the high strength steel lowest grades according to Table 2.2.5-2;

.2 when joining high strength hull structural steel to the same and also joining high strength steel to higher or normal strength hull structural steel, controlled diffusible hydrogen type welding consumables, having the classification indices H5 or H10, according to Table 4.2.3.4, shall be used;

.3 the use of a single-run and two-run welding procedure for high strength steel welded joints is not recommended. The Register's approval may be given only based on the additional tests according to the program approved by the Register;

.4 the use of an electroslag and electrogas welding for high strength steel welded joints is not recommended. The Register's approval may be given only based on the additional tests according to the program approved by the Register;

.5 the use of a multi-arc and one-side welding on backs of different types for high strength steel welded joints is not recommended. The Register's approval may be given only based on the additional tests according to the program approved by the Register;

.6 rutile and oxide-coated electrodes shall not be used for high strength steel structures welding;

.7 the use of all grades welding consumables, tested according to requirements in **4.6**, for high strength steel welding is permitted only for base metal joints up to 70 mm thick. The use of welding consumables for welding of steel over 70 mm thick may be allowed only based on the additional tests according to the program approved by the Register;

.8 for grades Y89 and Y96, where the design requirements permit undermatching weld joint, then welding consumables of the lowest grade acceptable in accordance with the requirements of Table 2.2.5-2 for welding of high strength steel may be used. The said conditions shall be agreed with the Register (technical justification shall be presented) and indicated during the issue of Welding Procedure Approval Test Certificate.

2.2.6 Choice of welding consumables grades for welding of hull structural steel structures operating at low temperatures.

Welding consumables for welding of hull steel structures operating at low temperatures shall be used in accordance with requirements in Table 2.2.6. Besides, when grades of welding consumables for welding of higher strength steels with the index F are specified, the requirements listed in **2.2.4** shall be followed including the following additions:

.1 depending on the function and operational conditions of structures, the Register may specify the higher grade of welding consumables (for instance, 5Y instead of 4Y and 5Y40 instead of 4Y40);

.2 the use of Grades 4Y46 and 5Y46 welding consumables, intended for high strength steel welding, is subject to additional agreement with the Register.

Таблиця 2.2.6

Grade of welding consumables	Grade of hull structural steel		
	F32	F36	F40
4Y, 4YS, 4YT, 4YTM, 4YV	+	+	–
4Y40, 4Y40S, 4Y40T, 4Y40M, 4Y40TM, 4Y40V	+	+	+
5Y, 5YS, 5YT, 5YM, 5YTM, 5YV [1]	+	+	–
5Y40, 5Y40S, 5Y40T, 5Y40M, 5Y40TM, 5Y40V [1]	+	+	+
4Y42, 4Y42S, 4Y42M	–	+	+
5Y42, 5Y42S, 5Y42M [1]	–	+	+
4Y46, 4Y46S, 4Y46M	–	+[2]	+
5Y46, 5Y46S, 5Y46M [1]	–	+[2]	+
[1]Refer to **2.2.6.1**. [2]Refer to **2.2.6.2**.			

2.2.7 Assignment of welding consumable grades for welding of hull structural aluminium alloys.

Welding consumables for welding hull structural aluminum alloys depending on their grade shall be used in compliance with the requirements in Table 2.2.7-1.

The practical areas of application for the most common international and national filler materials, which shall be followed in their approval, are given in Table 2.2.7-2.

Table 2.2.7-1

Grade of welding consumable	Hull structural aluminium alloys											
	International						National					
	5754	5086	5083	5383, 5456	5059	6061, 6005A, 6082	1530	1550	1561	1565ч	1575	(AlSiMgMn)
RA/WA(5754)	+	–	–	–	–	–	+	–	–	–	–	–
RB/WB(5086)	+	+	–	–	–	–	+	–	–	–	–	–
RC/WC(5083)	+	+	+	–	–	+	+	+	–	–	–	+
RC/WC(5383)	+	+	+	+	–	+	+	+	–	–	–	+
RC/WC(5456)	+	+	+	+	–	+	+	+	–	–	–	+
RC/WC(5059)	+	+	+	+	+	+	+	+	+	+	–	+
RD/WD(6061)	–	–	–	–	–	+	–	–	–	–	–	+
RD/WD(6005A)	–	–	–	–	–	+	–	–	–	–	–	+
RD/WD(6082)	–	–	–	–	–	+	–	–	–	–	–	+
R1/W1(1530)	+	–	–	–	–	–	+	–	–	–	–	–
R2/W2(1550)	+	+	+	–	–	+	–	–	–	–	–	+
R3/W3(1561)	+	+	+	+	+	+	+	+	+	+	–	+
R3/W3(1565ч)	+	+	+	+	+	+	+	+	+	+	–	+
R4/W4(1565ч)	–	–	–	–	+	–	–	–	+	+	+	–
R4/W4(1575)	–	–	–	–	+	–	–	–	+	+	+	–
R5/W5(AlSiMgMn)	–	–	–	–	–	+	–	–	–	–	–	+

Table 2.2.7-2

Grade of welding	Hull structural aluminium alloys

consumable		International						National					
Designation	Code of chemical composition	5754	5086	5083	5383, 5456	5059	6061, 6005A, 6082	1530	1550	1561	1565ч	1575	(AlSiMgMn)
International materials [1]													
–	AlMg3	+	–	–	–	–	–	+	–	–	–	–	–
5356	AlMg5	+	+	+	–	–	+	+	+	–	–	–	+
5183	AlMg4,5Mn	+	+	+	+	–	+	+	+	–	–	–	+
–	AlMg6Mn1	+	+	+	+	+	+	+	+	+	–	–	+
National materials [2]													
СвАМг3	AlMg3	+	–	–	–	–	–	+	–	–	–	–	–
СвАМг5	AlMg5	+	+	+	–	+	+	+	+	–	–	–	+
СвАМг61	AlMg6Mn1	+	+	+	+	+	+	+	+	+	+	–	+
Св01597	–	–	–	–	–	+	–	–	–	+	+	+	–

[1] Designations of the most common filler materials for welding international aluminium alloys (welding processes 141 = TIG and 131 = MIG) in accordance with ДСТУ EN ISO 18273 or applicable ISO or EN standards.

[2] Designations of welding wire brands for welding national aluminium alloys used in shipbuilding in accordance with the Russian standard GOST 7871 (welding processes 141 = TIG and 131 = MIG).

2.3 WELDING IN SHIP MACHINERY CONSTRUCTION

2.3.1 The present requirements apply to the welding of ship machinery sructures manufactured using base materials and welding consumables, which are in accordance with Part XIII "Materials" and this Part. Manufacturing of structures from materials not regulated by the Rules shall be effected on agreement with the Register.

2.3.2 Welding consumables for machinery and machinery installations shall be chosen on the basis of steel grades used for the manufacture bearing the requirements of **2.2.4 – 2.2.6** in mind.

2.3.3 When structures are intended for operation at high temperatures or in a chemically aggressive medium, those conditions shall be taken into account when selecting the welding consumables.

2.3.4 For welding of steel parts 30 mm and more in thickness used in ship machinery construction, welding consumables shall be applied, which would guarantee the cold cracking resistance of the weld, or the manufacturer shall take technological measures (preheating, heat treatment, limiting of ambient air temperature during welding, etc.) to eliminate cold cracking.

2.3.5 The welds in structures, which shall be exposed to dynamic loads, shall be executed with full penetration. The transition from the base metal to the weld shall be smooth.

2.3.6 When shafts for ship shafting or crankshafts are fabricated, the application of welding may be allowed by the methods approved by the Register on submitting the data confirming their continuous successful application results.

For this purpose, the necessary conditions are that all the welds were subjected to non-destructive testing and the fatigue strength of welded joints adopted in the calculations were guaranteed.

The amount of experimental welding necessary and the test program shall be agreed with the Register before welding is commenced.

2.3.7 The application of welding including building-up, metal pulverization and other similar methods, when manufacturing or repairing ship machinery items, may be permitted if tests carried out in accordance with the procedure agreed with the Register and confirming the possibilities of applying the method in question at a particular works yield good results.

Repairs to ship shafts of carbon steel (with up to 0,45 % carbon content), which are worn or have surface cracks, may be performed by building-up, provided the amount of wear or the depth of cracking does not exceed 5 % of the shaft diameter, but it shall not be over 15 mm.

2.4 WELDING OF STEAM BOILERS AND PRESSURE VESSELS

2.4.1 Welded joints of boilers shall be so marked as to make it possible to identify the operator having performed the welding.

Longitudinal and circumferential welds of boiler shells shall be made with a back-sealing run except when the efficiency factor of welded joints φ according to Table 2.1.6.1-1, Part X "Boilers, Heat Exchangers and Pressure Vessels" is adopted to be 0,7 or less.

Cuts and openings in the boiler shell shall not, as far as possible, cross circumferential or longitudinal joints in the shell.

The possibility of fixing, by welding, any fastenings, catches and other parts to the boiler shell shall be specified in the documentation submitted to the Register.

The longitudinal and circumferential joints of headers, boiler shells and pressure vessels shall be buttwelded.

2.4.2 Welding consumables for boilers and pressure vessels shall be chosen on the basis of steel grades used for the manufacture bearing the requirements of **2.2.4** to **2.2.6** in mind.

2.4.3 Rutile and oxide-coated electrodes are not permitted for the welding of boilers and pressure vessels of Class I (refer to **1.3.1.2**, Part X "Boilers, Heat Exchangers and Pressure Vessels"). They are permitted for boilers and pressure vessels of Class II and Class III, provided those structures are manufactured of carbon steel and the thickness of parts to be welded is not in excess of 20 mm.

2.4.4 The heat treatment of boilers and pressure vessels shall be determined according to standards or by the data presented by steel works.

The welded joints in parts, which cannot be heat treated as a whole for stress relieving because of their dimensions or inappropriate structure, may be subjected to local heat treatment on agreement with the Register. Such a treatment shall be performed by uniform warming-up of a sufficiently wide area along the weld (for a distance about 6 times the plate thickness on both sides of the joint) so as to prevent the spread of thermal stresses to other areas of the parts involved. Local treatment by means of a welding torch is prohibited.

2.4.5 When openings in boilers are closed up by means of plugs fixed by welding, the requirements of national standards shall be met.

2.4.6 Worn-out shell plates of boilers and pressure vessels may be repaired by building-up only on agreement with the Register.

The built-up area shall not exceed 500 cm^2, and its depth shall not be over 30 % of the plate thickness. If these conditions cannot be met, the faulty area shall be repaired by inserting a new plate.

2.4.7 When manufacturing boilers, heat exchangers and pressure vessels belonging to Class I or Class II (refer to **1.3.1.2**, Part X "Boilers, Heat Exchangers and Pressure Vessels"), test samples shall be prepared to check up the mechanical properties of welded joints in the case of unique products being manufactured, serial production, on the prototype product, alterations in the structure of main units and parts, application of new materials and welding processes.

Test samples for products belonging to Class III shall be prepared, if required by the Register.

2.4.8 The test samples shall be attached to the longitudinal joint of a boiler or pressure vessel in such a way that the test plate joint is a continuation of the joint of the boiler or pressure vessel. The welding procedure shall be the same as employed in the welding of the boiler or pressure vessel joint.

A test assembly thus prepared shall provide one transverse tensile test piece, two transverse bend test pieces, three impact test pieces cut out according to Fig. 4.3.3.1.

Specimens for structures belonging to Class III shall be prepared, if required by a surveyor to the Register. The requirements for cutting specimens from the test assembly and for testing them shall be in accordance with the requirements of **4.2.2**.

2.5 WELDING OF PIPELINES

2.5.1 The type of welded joints in pipes shall comply with standards.

2.5.2 Welding consumables for pipelines shall be chosen on the basis of steel grades used for the manufacture bearing the requirements of **2.2.4** to **2.2.6** in mind.

2.5.3 In the welded butt joints of pipes full root penetration shall be provided. Welding with the use of removable backing rings is permitted.

2.5.4 The use of the remaining backing rings in butt joints is permitted in pipelines where those rings do not adversely affect the performance.

The remaining backing rings shall not be used for flange-to-pipe butt joints.

2.5.5 The welded joints in pipes shall be heat treated in the case of pipes of low-alloyed steels and in the case of gas welding of main steam pipelines operating at temperatures above 350°C.

2.5.6 When welding pipes of chrome-molybdenum steel containing 0,8 % or more of chromium and more than 0,16 % of carbon, the edges to be welded shall be preheated to a temperature 200 to 230°C. This temperature shall be maintained during welding.

2.5.7 Before welding, the edges of copper pipes with a wall thickness 5 mm and over shall be heated to a temperature 250 to 350°C.

Copper-nickel pipes shall be welded without preheating. For connecting of copper-nickel pipelines the use of brazing is not permitted.

2.6 WELDING OF CASTINGS AND FORGINGS

2.6.1 Regardless of ambient air temperature, the welding of steel castings and forgings shall be effected with preheating, or other technological measures shall be taken to guarantee that the requirements for welded joints are satisfied in the following cases:

.1 for steel castings and forgings with carbon content exceeding 0,25 %;

.2 for steel castings and forgings with carbon content exceeding 0,23 % when those castings and forgings are part of the hull structure of polar Classes **PC1-PC6**, Baltic ice classes **IA Super, IA, IB, IC, Ice4 – Ice6** ice class ships and with the sign **Icebreaker** (castings and forgings of sternframes, stems, propeller shaft brackets, etc.).

2.6.2 The temperature of preheating and the heat treatment procedure for castings and forgings shall be determined depending on the design, size and service conditions of the structure concerned in accordance with **2.1.4, 2.1.12, 2.1.16**.

2.6.3 The faults in castings and forgings may be repaired by welding only when the steel in question has been previously checked for weldability with due regard to the service conditions of the cast or forged part.

Repairs of faults by welding shall generally be undertaken prior to the final heat treatment. After it, rewelding is permitted only by way of exception.

Repetitive faults in castings and forgings are not permitted for repair by welding.

2.6.4 The rewelding of faults in castings shall be made after sprues and heads have been removed and the castings thoroughly cleaned of sand, scale and extraneous inclusions.

The surface subject to repair shall be ground to sound metal so as to provide for penetration throughout the welded area.

The surfaces of areas to be rewelded shall be gently sloped and shall not have sharp corners.

2.7 WELDING OF CAST IRON

2.7.1 Repair of cast iron by welding is permitted on agreement with a surveyor to the Register using a welding process approved by the Register and proceeding from the results of testing by a program agreed with the Register.

2.8 WELDING OF CLAD STEELS

2.8.1 Welding processes for clad steel shall be approved in accordance with Section **6**, Part III "Technical Supervision during Manufacture of Materials" of Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships, the welding consumables _ in accordance with Section **4**.

The edge preparation for welding shall be in accordance with national standards or drawings approved by the Register.

Preparation of the edges shall be effected by machining or grinding.

The edges of parts to be assembled shall fit each other closely and shall not be out of alignment on the clad surface.

2.8.2 The corrosion resistance of weld metal on the clad side shall be equal to that of the cladding.

The thickness of the corrosion-resistant layer of the weld shall not be less than that of the cladding.

The chemical composition of weld metal on the clad size (except the root zone) shall correspond to the chemical composition of the cladding metal.

2.8.3 As a rule, the weld shall be made first on the plate surface, which is opposite to the clad surface and then on the clad side.

Welding on the non-clad side shall be so done that no melting of the cladding layer occurs.

Prior to welding on the clad side the root of an unalloyed weld shall be cut out to sound metal by machining or grinding. For a back-sealing run the same welding consumables shall be used as for welding the cladding layer.

The cladding layer shall be welded so as to reduce, as far as possible, the interpenetration of alloyed and unalloyed materials

For welding the cladding layer, welding electrodes and wires of the smallest diameter possible shall be used. The welding shall be carried out, as far as possible, at a low rate of energy input. The weld on the clad surface shall be made up of two layers at least.

In welding the cladding layer, transverse weaving of electrode is not permitted.

Where the top layer width is such that it shall be deposited in several runs, the last run shall be made along the middle of the weld.

2.8.4 In welding pipes of clad steel, where welding on both sides is not feasible, the entire joint shall be welded with the use of welding consumables suitable for the cladding material.

When welding clad plate steel, the entire joint shall also be welded with the use of welding consumables suitable for the cladding material.

2.9 BRAZING

2.9.1 Brazed joints in structures specified in **1.1.1** are subject to survey by the Register. They shall be executed in conformity with standards or technical documentation agreed with the Register.

2.10 WELDING OF ALUMINIUM AND ITS ALLOYS

2.10.1 Welding operations shall be performed by the most expedient method, which would ensure good quality joints of required strength with their chemical composition similar to that of the base metal and having sufficient corrosion resistance.

2.10.2 Wherever possible, welded joints shall be located in areas exposed to the lowest stresses.

As a rule, welding shall be effected in the down-hand position.

Weld reinforcement may be removed only subject to the special approval of the Register.

2.10.3 Immediately before welding (tack welding) the edges of aluminium or aluminium alloy components shall be degreased with special solvents (acetone, alcohol, etc.) and then cleaned with wire brushes. Jacked spots are also to be cleaned with a steel wire brush before welding. In the case of multirun welding, each run of deposit shall be brushed before the next run is applied.

2.10.4 Welding consumables of aluminium and aluminium alloys shall have their surfaces cleaned from dirt and oxide film.

2.10.5 For aluminium alloys, welding on remaining or removable backings is permitted. The backings to be removed after welding shall be of stainless steel. The backings that are not removed shall be made of the same kind of alloy as that used for the parts to be welded.

2.10.6 In the case of a double-welded joint, before a sealing run is applied to the back of the weld, a groove shall be made by root-run chipping, planing or milling to clean metal. Cutting out of the root by means of abrasive disks is not permitted.

2.10.7 Hot straightening of structures made of aluminium and aluminium alloys is permitted. The heating temperature range for straightening shall be within the limits corresponding to the properties of the alloy.

2.10.8 Where a flux is used, it shall, as a rule, be neutral. If, by way of an exception, the flux used was not neutral, it shall be carefully removed after welding.

2.10.9 On riveted structures made of aluminium alloys, all major welding operations shall be completed before riveting.

2.11 WELDING OF COPPER AND COPPER ALLOYS, HEAVY METALS AND OTHER NON-FERROUS METALS

2.11.1 Welding of copper and copper alloys as well as of heavy metals and other non-ferrous metals shall be carried out according to the standards and/or documentation approved by the Register.

2.12 WELDING OF HIGH STRENGTH STEELS

2.12.1 The welding consumables designed for welding of high strength steels shall be approved in accordance with **4.7**, and the welding processes _ in accordance with Section **6**, Part III "Technical Supervision during Manufacture of Materials" of Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

2.12.2 The process and procedure of welding shall be approved by the Register after fabrication testing by an agreed program. For this, the manufacturer of welded structures shall submit the documented preheating temperature, linear power comsumption during welding, postweld heat treatment, and temperature between runs.

The manufacturer shall use a welding condition recording system including the temperature between runs and submit the inspection results to the Register upon request.

2.12.3 Welded joints shall be made by multirun welding. Single-run welding may be permitted only on agreement with the Register. Each run shall be continuous with minimum arc fluctuations.

2.12.4 Arc firing outside the edges prepared for welding is not permitted.

Welding-on of temporary mounting fittings may be permitted provided the Register requirements for consumable materials and the local heating temperature are complied with.

As a rule, temporary fittings are removed by machining with subsequent dressing flush with the base metal surface.

Preliminary gas cutting shall be followed by the machining of the remaining part and by dressing.

2.12.5 The edges prepared by gas cutting shall be machined after such cutting. Roots shall be removed by machining only.

The heating temperature for straightening is subject to approval by the Register in each case. The required properties of the base metal and welded joint shall be ensured.

2.13 WELDING OF TITANIUM AND TITANIUM ALLOYS

2.13.1 Welding operations shall be performed appropriately to provide qualitative welding joint, its maximum strength with their chemical composition similar to that of the base metal.

2.13.2 Welding shall be performed in any welding position.

2.13.3 At welding bays the local air flow velocity shall not exceed 0,3 m/s. The measurement of the air flow velocity shall be performed with anemometers manually (hand-held anemometers). In this regard, welding workplaces in welding assembly bays shall be located so as to prevent any draughts and local air flows. Whenever necessary the welding area shall be protected.

2.13.4 At welding bays the work associated with formation of excessive emissions of fumes and gases is prohibited.

2.13.5 To ensure the removal of polluted and clean air feed welding production facilities (workshops) shall have air exhaust-and-forced ventilation. In cold time the supply air shall be heated up. Operation of ventilation installations and compressed-air tools in the workshops and at welding shall be arranged so as not to disrupt gas protection during welding.

2.13.6 6 Total illumination in working spaces during work shall not be less than 50 lux.

Except general illumination there shall be provided local lighting - directly at the workplaces:

not less than 75 lux - while checking the quality of welding joints by visual examination;

not less than 150 lux - during input inspection of welding consumables and the quality control of their preparation.

2.13.7 The ambient temperature of the spaces depends on their purpose and shall be:

not less than17°C - in spaces for preparation of welding consumables and degreasing solvents, vacuum annealing, etching, manufacture of shielding gas backing devices, store rooms for storage of packaged and accepted welding consumables, as well as test and measurement instrumentation;

not less than 5°C - in the spaces to carry out cleaning, gas cutting and welding works.

Welding operations performance is approved shall the temperature drop inadmissibly to 1°C, while preventing the safety of welding equipment from water freezing in the water hoses.

2.13.8 Relative air humidity in working spaces for preparation of filler metals and that in store rooms for packaged and accepted welding consumables shall not exceed 75 %.

During the period from May to September, an increase in relative humidity up to 80 % is admissible. At relative air humidity in store rooms being more than 80 %, the heating appliances shall be switched on.

2.13.9 Wall and floor liners of working spaces shall ensure easy dust elimination and shall not be a source of dust formation. The cement floor is permitted only in the area of access driveway.

2.13.10 Clean working spaces shall be maintained with periodic cleaning with a vacuum cleaner or other means, as well as frequent wet cleaning.

Wet cleaning in working spaces of wire and welding preparation shall be carried out as follows:

of floor - at least two times per shift (before work and during lunch break);

of equipment, jigging, shelving and assembled structures for welding - at least once a week;

walls at a height up to 3 m and structures where assembly and welding works are not performed - at least once a month;

walls at a height of over 3 m, windows, lanterns, crane gantries, pipeline ventilation - at the next minor repairs of a welding shop.

As of the equipment installation on the product wet cleaning of walls and structures above the product shall not be carried out.

2.13.11 During preparation of the components and structures to be welded the following shall be provided:

.1 mechanical treatment of welded edges and surfaces.

The quality of mechanical treatment of welded edges and surfaces is subject to acceptance by the Quality Control Department (QCD). After mechanical treatment the welded surfaces and edges as well as surfaces of the parts shall have the following roughness as per parameter Ra (not over):

20 µm - in the joints of steel plate structures of thickness over 15 mm made by any type of welding;

10 µm - in the joints of steel plated structures of thickness less than 15 mm, made by any type of welding and the pipeline design with wall thickness exceeding 5 mm made by any type of welding;

5 µm - in the pipe joints of thickness over 15 mm, made by any type of welding;

.2 dressing of the areas to be welded, as well as the adjacent surfaces.

Dressing shall be performed as follows:

in a mechanized or manual manner with brushes;

with abrasive disks followed by dressing with a file brush;

with boring cutter followed by dressing with a file brush; hand-scraping - in preparation of sheet and pipe welded joints;

with sandpaper - in preparation of welded joints in pipes.

From the oxidized surface parts of in way of the welds an oxidized layer shall be arranged at a depth of not less than 100 µm - in case of antifriction oxidation or to metallic blushing or - with protective oxidation;

.3 degreasing welded surfaces and edges with adjacent surfaces.

During the degreasing operation it is necessary to use special degreasing agents (aqueous washings, acetone, spirit, etc.) depending on the use of semi-finished products to manufacture structures. When applying aqueous washes, after washing areas shall be wiped dry with clean white calico napkins, and in case of application of acetone or spirit-dried in the air.

When welding pipelines to reduce the pore formation in the preparation of welded edges it is recommended to carry out a special cleaning including:

degreasing in an aqueous trisodium phosphate solution

etching in the solution of nitric (mass fraction of 30 - 40 %) and hydrofluoric acid (mass fraction of 3,5 - 6,0 %).

2.13.12 For quality assurance of welds where welding of titanium alloys is performed, required protection of the reverse side of welding joints shall be provided from effects of air (oxidation) with backing inert gas by methods of general protection of structures (in the spaces with inert controlled atmosphere or in vacuum) or local protection. Inert gas backing may be performed as follows:

with special gas protection arrangement removed along the weld or installed permanently;

feeding the internal volume of the design or its part;

with shielding gas backing filling the internal volume of piping.

2.13.13 Prior to welding operations it is necessary to check: operation of all the welding equipment joints and machinery as well as control circuits, gas protection systems and water cooling;

main and auxiliary materials available at the welding site and required to carry out welding operations;

inert gas pressure in cylinders directly connected to the welding stations.

2.13.14 Welding wire and filler rods from a storeroom shall be distributed to a welder at the required for work during one shift rate. Before the use of materials the welder shall check the wire surface and bars quality as well as their purity by wiping with a white coarse calico napkin (cloth).

Defective (substandard) and contaminated materials shall be refundable to the storeroom:

an annealing grey colour without metallic blushing:

wrinkles (wrinkled areas) as well as powdered deposit of any colour.

2.13.15 The quality of the performed weld is required to be assessed by the crater's surface colour:

silvery without a trace of annealing;

a pale yellow (straw) annealing colour is permissible;

other than light yellow (straw) annealing colours on the crater surface are considered impermissible.

During the oxidation of the crater to unacceptable annealing colours the welding shall be ceased, the factors causing metal oxidation shall be revealed and eliminated, and the weld (bead) is removed at the entire depth of penetration and length of oxidation.

It is prohibited to continue or finishing weld seams without eliminating the factors causing oxidation of the crater.

2.13.16 6 If the weld crater is of an admissible annealing colour, the quality of the protection of welds (beads) and base metal in the welding process shall also be assessed by their annealing colours as well as surface appearance. Conditional permissible annealing colours on the surface of the joints and base metal: light yellow (straw), brown and violet.

Unacceptable annealing colours and seams (beads) appearance:

blue, light blue, green and light green;

an annealing grey colour without metallic blushing;

wrinkles (wrinkled areas) as well as powdered deposit of any colour.

In case the conditional permissible annealing colours are available, the oxide film on the surface of welds (beads) and the base metal shall be removed. It is strictly forbidden to weld on the oxidized surfaces (with any annealing colour) and melt down on these areas.

Welds with impermissible annealing colours and appearance shall be removed at the entire depth of penetration.

Prior to welding the areas of welds (some beads) and the base metal surface shall be washed with a solvent after removal of oxidations and their dressing as well as during welding renewal after a break.

Notes: **1.** Permissible annealing colours at the crater surface (light-yellow-straw) as well as conditional permissible annealing colours at the surface of seams and base metal (light-yellow-straw, brown and violet) define the planar oxidation that is a thin oxide film easily removable while cleaning with a steel brush.

2. In case any annealing colour except light yellow (straw) is available on the crater surface, irrespective of an annealing colour on the surface of the performed bead, the latter may be oxidized throughout the entire section (associated with oxidation during welding of a liquid pool) and in this case it is subject to relative removal.

3. Impermissible annealing colours on the surface of seams (blue, blue, green and light green) are either a proof of surface oxidation of oxide film thickness not amenable to adequate removal while grinding with a steel brush, or of weld metal bulk (volumetric) oxidation which hardness is less than the base metal hardness.

Beads with unacceptable annealing colours are subject to relative removal.

4. A grey annealing colour without metal blushing as well as wrinkled areas (wrinkles) and powdered deposit of any colour on the welded bead are a proof of volumetric oxidation, and the seam shall be removed at the entire penetration depth.

2.13.17 After welding is finished the extended backing strips shall be removed, ends of details shall be cleaned and inspection of cleaned locations shall be performed.

2.13.18 It is recommended to carry out single-run welds at any kind of welding with no breaks.

While performing multirun welds, welding of each subsequent run shall only be carried out after cooling the previous one.

The main criterion of sufficient cooling shall be absence of annealing colours on the crater's and bead's surfaces.

2.13.19 Straightening shall be used to eliminate general and local distortions of steel plate structures arising during manufacture. Straightening of titanium alloy structures shall be made with arc heating. Straightening is permitted to be performed with multirun welds. The heating temperature when straightening shall agree with the properties of the alloy.

3. TESTING OF WELDED JOINTS

3.1 GENERAL

3.1.1 Non-destructive testing methods.

3.1.1.1 Non-destructive testing of welded joints may be effected by the following methods:

.1 visual testing (VT);

.2 magnetic particle testing (MT);

.3 penetrant testing, including dye penetrant testing, fluorescent penetrant testing and fluorescent-dye penetrant testing (PT);

.4 radiographic testing, including X-ray testing and gamma-ray testing (RT);

.5 ultrasonic testing (UT);

.6 tightness testing.

3.1.1.2 The scope of applicability of various non-destructive testing methods for various types of welded joints is specified in Tables 3.1.1.2-1 and 3.1.1.2-2. It is necessary to consider that radiographic and ultrasonic testing have different detectability characteristics for defects of various types and location.

Таблиця 3.1.1.2-1 **Generally accepted methods for detection of accessible surface imperfections for all types of welds, including fillet welds according to ДСТУ EN ISO 17635 or the applicable ISO or EN standards**

Materials	Testing method
Ferritic steel	VT, VT and MT, VT and PT
Austenitic steel	VT, VT and PT
Aluminium alloys	VT, VT and PT
Copper-nickel alloys	VT, VT and PT
Titanium alloys	VT, VT and PT

Таблиця 3.1.1.2-2 **Generally accepted methods of detection of internal imperfections for butt and T-joints with full penetration in compliance with ДСТУ EN ISO 17635 or the applicable ISO or EN standards**

Materials and type of joint	Nominal thickness of base metal t, mm		
	$t \leq 8$	$8 < t \leq 40$	$t > 40$
Ferrite butt joints	RT or (UT)	RT or UT	UT or (RT)
Ferrite T-joints and fillet joints	(UT) or (RT)	UT or (RT)	UT or (RT)
Austenitic butt joints	RT	RT or (UT)	RT or (UT)
Austenitic T-joints and fillet joints	(UT) or (RT)	(UT) and/ or (RT)	(UT) or (RT)
Aluminium butt joints	RT	RT or UT	RT or UT
Aluminium T-joints and fillet joints	(UT) or (RT)	or	UT or (RT)
Nickel and copper alloy butt joints	RT	RT or (UT)	RT or (UT)
Nickel and copper alloy T-joint and fillet joints	(UT) or (RT)	(RT) or (UT)	(UT) or (RT)
Titanium butt joints	RT	RT or (UT)	
Titanium T-joints and fillet joints	(UT) or (RT)	UT or (RT)	

Notes: Methods in parenthesis are only applicable with:

- the lower boundary of the base metal thickness for ultrasonic testing method is determined with the applied equipment and standards. In accordance with normative documents applied in shipbuilding ultrasonic testing for thicknesses of under 8 mm is not applied;
- for radiographic testing the upper boundary of its application of the base metal thickness is determined as per the capabilities of radiation sources and exposure time (refer to **3.2.4**);
- the capability of using radiographic testing for T-joints and fillet joints is calculated by the ratio of thickness of the welded metal in the radiographic testing direction to the total thickness of the base and welded metal in the radiographic testing direction (the use of radiographic testing is not feasible with a decrease in this ratio of less than 0,3);
- for materials with high degradation of the signals (austenitic steels, nickel and copper alloys) the use of ultrasonic testing method requires the use of special procedures.

Radiographic testing is the most effective for detecting and classification of three-dimensional inner discontinuities like pores, slags, metallic inclusions and lack of fusion in the weld's root and it is less effective for detection of plane (two dimensional) discontinuities like cracks and poor fusion especially if their plane does not coincide with the direction of radiographic testing.

On the contrary, ultrasonic testing is the most effective for the detection of plane (two dimensional) defects which are the most dangerous and impermissible in welded structures irrespective of their linear dimensions and location. Ultrasonic testing enables to determine the depth of the detected defects location which is essential for extraction and repair of defective weld parts. It is necessary to consider that this nondestructive testing method has limited capability for the classification of three-dimensional discontinuities and they are assessed in conditional numeric values.

3.1.2 Requirements for testing laboratories and personnel.

3.1.2.1 Non-destructive testing and quality assessment of welded joints shall be performed by testing laboratories (centres) which competence and status comply with the requirements for accreditation in accordance with national or international standards.

The Recognition (Accreditation) Certificate issued by the Register or by other authorized national body is a document confirming competence of the testing laboratory. In the latter case the copy of the Certificate with supplements shall be submitted to the Register surveyor prior to start of welding.

Requirements for testing laboratories and the procedure of their recognition by the Register comply with the provisions of Section **9**, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

3.1.2.2 Non-destructive testing and quality assessment of welded joints shall be performed by specialists with the relevant training, certification and practical experience in the specific non-destructive testing method which shall be proved by documents. Assessment of the qualification level and certification of personnel in non-destructive testing shall be performed in accordance with ДСТУ EN ISO 9712 or the applicable ISO or EN standards, as well as other documents recognized by the Register. Bodies performing personnel certification in non-destructive testing shall comply with general requirements of ДСТУ EN ISO/IEC 17024 or the applicable international standards ISO/IEC or EN/IEC.

3.1.2.2.1 Certification levels.

A person certified in accordance with ДСТУ EN ISO 9712 or the applicable ISO or EN standards, may be certified in one or more of the following three levels.

Level I.

The person certified by Level I shall be competent to implement the non-destructive testing in accordance with the NDT instructions and under the supervision of personnel of Level II or III. As part of the scope executed covered by the Certificate, Level I personnel can be qualified by the employer to perform the following steps in accordance with the instructions of non-destructive testing and in the field of competence, specified in the Certificate:

installation of non-destructive testing equipment;

implementation of control;

keep records and assess testing results;

draw a report on the results.

The personnel certified by Level I, shall not bear responsibility for the choice of method or testing procedures, nor of assessment of results.

Level II.

The person certified by Level II, shall have the competence to implement the non-destructive testing in accordance with established procedures. Within the scope of the Certificate, Level II personnel may be entitled by the employer to:

select the non-destructive testing method to implement non-destructive testing procedure;

determine the limitations on the application of the testing method;

the use of sets of regulations (codes of practice), standards, specifications and procedures for nondestructive testing to make up practical instructions adapted to the actual operating conditions:

implementation of parameters set-up and check of the equipment tuning;

performance monitoring and supervision of control;

interpretation and assessment of results in accordance with the relevant legal regulations, standards, specifications and procedures;

preparation of NDT instructions;

execution and control of all the tasks of Level II or below Level II;

ensure personnel management as per Level II or below Level II;

preparation of a report on the results of non-destructive testing (NDT).

Level III.

The person certified by Level III, shall show competence to implement and implement di-rectly the non-destructive testing for which he is certified. Within the scope of the Certificate, Level III personnel may be entitled by the employer to:

accepting full responsibility for the day premises (spaces) for testing or examination centre and personnel;

framework, review of editorial and technical correctness and approval of NDT instructions and procedures;

interpretation of sets of regulations (codes of practice), standards, specifications and procedures;

assignment of specific testing methods, procedures and instructions used by non-destructive testing; performance and control of all the tasks of all the levels;

provision of management at all levels;

taking part in commissions on certification exams for non-destructive testing specialists of all levels in compliance with the requirements of the applicable standard and in agreement with the certification body.

Level III personnel shall show:

competence in the assessment and interpretation of the results in the framework of the existing sets of regulations, standards, specifications and procedures;

sufficient working knowledge of the materials, technology and manufacturing process to select the method of non-destructive testing and render assistance in setting assessment criteria, where they do not exist;

general knowledge of other NDT methods.

In view of the above the following qualification requirements for personnel allowed to perform nondestructive testing of welded joints shall be adhered:

.1 the scope of the Register recognition of the qualification of specialists in ultrasonic testing is, as a rule, limited by the normative documents (standards) used for their special and practical testing during certification;

.2 specialists of at least Level I qualification are approved for radiographic testing (without the right to issue conclusions) and of at least Level II qualification - for other non-destructive testing methods;

.3 issue of conclusion on the specific non-destructive testing method, check of the equipment operability, as well as drawing up of non-destructive testing charts in accordance with valid normative documents shall be performed by specialists of at least Level II qualification;

.4 agreement of non-destructive testing charts, assignment of specific testing methods, procedures and used NDT instructions as well as interpretation of code of practice, standards, specifications and procedures shall be performed by specialists of at least Level III qualification.

3.1.3 Testing plan and records.

3.1.3.1 Unless agreed otherwise, the testing plan for welded joints of hull structures and pipelines, as well as for particular products manufactured under the Register technical supervision shall be prepared and submitted to the Register for approval. In the latter case the necessary information may be provided on the relevant drawings without drawing up a separate document. The testing plan shall contain the following information:

.1 details and welded joints subject to testing during the acceptance of welded structures;

.2 scope and methods of testing;

.3 testing locations determined in advance;

.4 requirements for quality assessment of welded joints;

.5 testing standards or written specifications.

3.1.3.2 Upon completion of welding operations on a structure the inspection authority of the manufacturer determines non-destructive testing locations (areas) according to the testing plan approved by the Register. The Register reserves a right to change location of some non-destructive testing areas or enlarge the scope of inspections.

3.1.3.3 Records on the performed inspections and testing shall be prepared for all types of testing (initial, additional and repeated after repair) and submitted to the Register surveyor together with the reports confirming the results of non-destructive testing. Conclusion on non-destructive testing results for welding joints shall contain the information specified in **3.2.6**.

3.1.3.4 Results of repeated testing (after repair) shall be separated in records.

Conclusion on non-destructive testing results shall be signed by a person having performed testing (non-destructive testing operator) and by a person responsible for testing duly authorized by the testing laboratory.

3.1.3.5 Records on the welded joints non-destructive testing results shall be kept at the firm for at least 5 years and be submitted, if necessary, upon the Register reques.

3.1.4 Non-destructive testing specification.

Non-destructive testing of welded joints shall be performed in accordance with the approved specifications (procedures) which shall contain at least the following information (if applicable):

.1 applied testing standards;

.2 materials and size;

.3 welding process and type;

.4 reference to the welding procedure specification;

.5 type of joint and size;

.6 main and auxiliary equipment;

.7 conventional sensitivity of testing and tuning methods with indication of applied calibration blocks and/or standard specimens;

.8 necessity and method of sensitivity correction;

.9 specification of parameters of detected defects (discontinuities, wrong size or shape) subject to assessment;

.10 requirements for tuning and calibration of applied equipment;

.11 forms of records issued upon test results;

.12 requirements for personnel qualification in accordance with the international or national standards;

.13 quality assessment criteria for the product acceptance.

3.1.5 Requirements for acceptance non-destructive testing of welded joints.

3.1.5.1 Acceptance non-destructive testing of welded joints shall be carried out (unless otherwise specified) after completion of all welding and straightening work prior to painting or priming, or prior to application of galvanic and other coverings.

During welding of higher strength steels structures at least 48 h shall pass between completion of welding and start of acceptance testing.

Notes: 1. . If a manufacturer can submit a documentary evidence of resistance to cold cracking for the applied materials and welding procedure, the time between the completion of welding and start of testing may be reduced for A/F40 or lower grade steels up to 40 mm thick.

2. This requirement does not cover operational technical testing performed during manufacture of products in accordance with the requirements of technical regulation (e.g., the layer testing of welded joints by visual testing, testing of welded joints with partially filled groove etc.).

3. For stem structures of icebreakers and ice class ships, at least 72 h shall pass between the completion of welding and start of acceptance testing of welded joints.

3.1.5.2 All welded joints shall be initially subjected to acceptance based upon results of visual testing of 100 % length on both sides of joint (if this is technically feasible). All impermissible defects and deficiencies as per form and size of joint as well as other defects preventing non-destructive testing by other methods shall be eliminated, and locations of repair shall be repeatedly accepted by the welding structures manufacturer's control body.

The Register reserves a right to require additional testing areas by relevant methods in those locations where visual testing detected defects indicative of a serious breach of the welding procedure.

3.1.5.3 If welded joints are subjected to heat treatment the final acceptance testing shall be performed upon its completion.

3.1.5.4 A repeated non-destructive testing prior to the welded structures commissioning (handling to the customer) or at their final acceptance may be required if these structures were subjected to loads not provided for normal operation (e.g. during transportation to the place of assembly, proof load testing or testing by pressure exceeding design operating values). Methods and scope of such testing shall be approved by the Register.

3.1.5.5 Impermissible defects detected at any testing stage of welded joints are subject to mandatory repair. A repeated repair of the same area of the welded joint is allowed only when specified in the documentation agreed with the Register. Repair of internal defects on the same weld length is usually not allowed more than twice..

3.1.5.6 If cracks are detected during testing of welded joints the following measures shall be taken:

.1 the whole length of the technologically independent welded joint made by the welder having performed a rejected weld shall be tested. All short welds (less than 1 m) in a block or assembly performed following the similar (to the rejected) welding procedure shall be tested;

.2 welding following the similar welding procedure specification shall be suspended;

.3 reasons for cracking shall be revealed and eliminated and the measures taken for their elimination shall be reported to the Register surveyor. If necessary, the welding procedure specification shall be corrected to be repeatedly submitted for the Register approval.

Notes: 1. Technologically independent welded joint is a continuous joint with the same section and edge preparation performed according to the same welding procedure specification in one or continuously changing welding position.

2. Butt welds of flat bulb and T-section steel parts as well as T-joints with full penetration of branches with plating, decks or bulkheads are considered as short welds.

3.1.5.7 If defects other than cracks (refer to **3.1.5.6**) are detected during testing of welded joints the following actions shall be taken:

.1 testing shall be continued in areas adjacent to the rejected one from both sides until satisfactory results are gained;

.2 additional testing of two new areas shall be performed according to **3.1.5.8** per one rejected area;

Note. This requirement does not cover testing areas adjacent to the rejected one and specified to detect the weld defective area according to **3.1.5.7.1**.

.3 four similar welds performed by the same welder following the same welding procedure specification: two antecedent and two consecutive, shall be additionally tested as per short welds;

.4 if results of additional testing according to **3.1.5.7.2** and **3.1.5.7.3** bear witness of the systematic character of impermissible defects, then all technologically independent welded joints or short welds in a block performed by one welder following one welding procedure specification shall be tested along the whole length;

.5 if during initial and additional testing 50 % and more of the technologically independent welded joint length or of the number of similar short welds in a block are tested and it is established that further testing is required, then the whole length of the joint shall be tested or all similar short welds in a block shall be tested.

3.1.5.8 When specifying additional testing areas according to **3.1.5.7.2** the following shall be followed:

.1 for circular butt joints between blocks and assembly butt joints additional testing areas shall be located somewhere in the middle between the areas tested earlier and assessed "fit";

.2 for intrablock welded joints additional testing areas shall be located on joints of which initial radiographic and ultrasonic testing was not carried out;

.3 if during initial testing at least one area was tested on all intrablock joints, additional testing shall be carried out on the welded joint with the defective area;

.4 if an area with intersection of welded joints was tested, additional testing areas shall be located on the weld with impermissible defect.

3.1.5.9 If during additional radiographic or ultrasonic testing the welded joint area quality is assessed "fit", the testing is stopped. If the additional testing area quality is assessed "unfit", the testing shall be continued according to **3.1.5.7** until satisfactory results are gained.

3.1.5.10 The following shall be observed during testing of welded joints after repair of impermissible defects:

.1 testing after repair of the whole technologically independent joint rejected upon the results of radiographic or ultrasonic testing shall be carried out in full scope by all testing methods provided by technical documentation for the acceptance testing of this joint;

.2 testing of separate areas of the welded joint rejected upon the results of radiographic or ultrasonic testing shall be performed after repair along the whole length by the same methods which were used for detection of repaired defects;

.3 quality assessment and acceptance of repaired welded joints shall be carried out following the same criteria as during the initial testing;

.4 if no impermissible defects are detected in the welded joint after repair, it is assessed "fit";

.5 if defects are detected in the welded joint after repair – refer to **3.1.5.5**.

3.1.5.11 When shell plating welds are tested, the radiograph shall be located at the intersection of the weld axes so as to partially cover also the seam as shown in Fig. 3.2.1.11-1.

In ultrasonic testing areas wider than 100 mm shall be tested on each side of the butt as shown in Fig. 3.2.1.11-2.

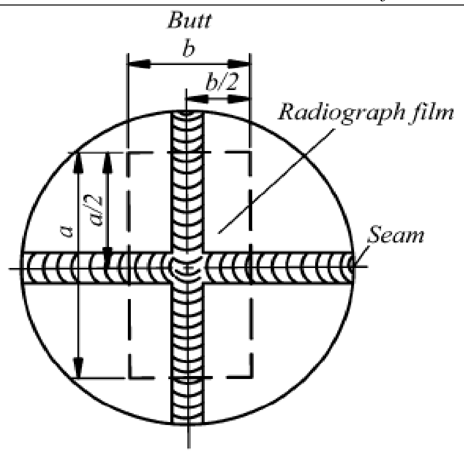


Fig. 3.1.5.11-1: *a* – length of radiograph equal to ≈ 500mm; *b* – width of radiograph equal to ≈ 100mm

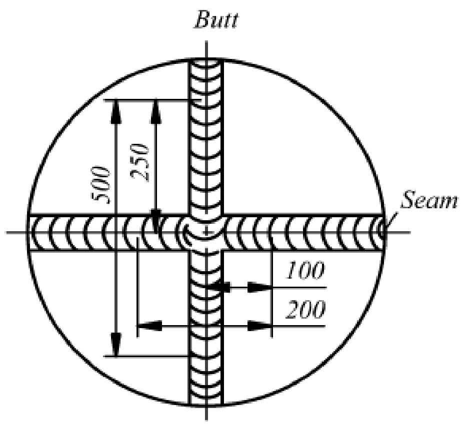


Fig. 3.1.5.11-2

3.2 CARRYING-OUT AND BASIC PARAMETERS OF NON-DESTRUCTIVE TESTING OF WELDED JOINTS.

3.2.1 Visual and measuring testing of welded joints (visual examination and measurement).

3.2.1.1 Visual and measuring testing of welded joints shall be performed in compliance with ДСТУ EN ISO 17637 or the applicable ISO or EN standards, or other international and national standards recognized by the Register.

3.2.1.2 Visual testing of welded joints shall be performed to reveal the weld surfaced imperfections and affected zone including (marking as per ДСТУ EN ISO 6520 or the applicable ISO or EN standards):

cracks (100, 104);

undercuts (5011, 5012, 5013);

unfilled craters, sags, runs, unfilled bevel (2025, 506, 509, 511);

surfaced blowholes (2016);

lacks of fusion in the root of a single-sided weld, concave deformation-shrinkage grooves in theweld root as well as excessive penetration-sagging in the weld root (4021, 515, 504);

surfaced pores and poor fusion (2017, 401); root porosity (516);

arc burns - stains of short circuits (601);

wrong weld section modulus - non-smoothness of conjuction with the base metal (505);

exceeding weld reinforcement (502, 503);

pimpling and scaling (514);

melted metal spatter (602);

correctness of the seal welding of crossing welds and free edges.

3.2.1.3 Visual testing of welded joints and affected zone shall be performed along the entire weld length on both sides accessible for examination (testing) before they can become inaccessible during further structure assembly except for absence of access to the weld reverse side in one-side welded joints.

3.2.1.4 Prior to visual testing weld and affected zone surface shall be cleaned from metal spatter, slag, soot and other and kept clear of protective coatings.

3.2.1.5 Visual testing shall be usually carried out without use of special optical instruments. Magnifying glasses with not more than 10X magnification may be used.

The illumination of the surface under control shall be at least 350 lux with the advised (recommended) value of 500 lux.

To perform visual and measurement examination an access to the controlled welded joint shall be provided at a distance of about 600 mm at the angle (angle) of examinationof at least 300 (refer to Fig. 3.2.1.5). In case when for the places which are not easily accesible the accessibility of the item under control (tested surface) in compliance with 3.2.1.5 can not be implemented, it is necessary to use mirrors, borescopes, flexible fiber optic cables or video cameras.

To increase the contrast between the imperfections and the background additional sources of illumination can be used.

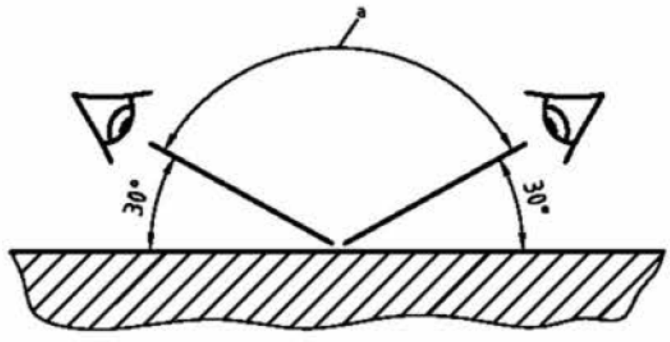


Fig. 3.2.1.5 Access for testing the surface at the visual and measurement examination

3.2.1.6 Where the results of visual examination are inconclusive, for example, where serious doubts exist that cracks exist, one of the following methods shall be additionally used to detect surfaced imperfections:

magnetic particle method of testing;

penetrant method of testing;

grinding with abrasive tool with subsequent etching by reagent used for detecting macrostructure.

3.2.1.7 Measurement testing of welded joints shall be carried out to check (marking as per ДСТУ EN ISO 6520 or the applicable ISO or EN standards):

toe weld (505);

weld reinforcement (502, 503);

leg length of a fillet weld (5213, 5214);

fillet weld asymmetry (512);

height and extension of undercuts (5011, 5012, 5013);

pimpling and scaling heights as well as values of sinking between the weld beads (514);

diameter of surface pores (2017);

lacks of fusion and concave deformation (shrinkage) depths in the root of one-sided weld (4021, 515);

exceeding penetration heights (504);

depths and extensions of metal leaks as well as sizes of unfillings of the edges groove (509, 511);

sagging values if required (506);

linear deflection values (507);

length and pitch of interrupted (non-continuous) weld.

Measurement testing is applied to check the geometric dimensions of the prepared for welding joints, including assembly clearances, mismatch welded edges peaks, shapes and dimensions of the edge preparation.

3.2.1.8 The measurement testing of the welds shall be carried out after visual examination or simultaneously with it. Measurement of welds shall be made not less than every meter connection, but there shall be at least one measurement at each of technologically independent connections (refer to Note 1 to **3.1.5.6**). At that the measurements of welded joints shall be first carried out at points where deviations from specified dimensions are suspected after a visual testing. Measuring the dimensions of connections with an intermittent weld shall be made on a sampling basis.

3.2.1.9 To perform measurement testing of welded joints there shall be applied measuring tools relevant to the Guidelines of Annex A to ДСТУ EN ISO 17637 or the applicable ISO or EN standards.

3.2.2 Welded joints penetrant testing.

3.2.2.1 Welded joints penetrant testing including dye penetrant testing, fluorescent penetrant testing and fluorescent-dye penetrant testing (PT), shall be applied and effected in accordance with the written specifications (procedures) developed on the basis of ДСТУ EN ISO 3452 or the applicable ISO or EN standards (Parts 1 - 6) or other international and national standards recognized by the Register.

3.2.2.2 Specifications for performing penetrant testing shall contain at least the following details and requirements:

minimum testing sensitivity and applicable control (reference) specimens (calibration equipment);

requirements for the prepreparation of the surface tested;

degreasing and backing of the surface tested prior to the penetrant application;
instructions on the details of the method application according to the temperature-controlled surface or restrictions on the temperature range for particular developers;
type of indicator penetrant;
applicable purifier and developer; coating and removal of indicator penetrant;
drying time (conditioning before removal) of indicator penetrant;
developer application and the development time;
illumination conditions for testing.
3.2.2.3 The tested surface shall be cleaned and clear of scale, rust, slag, dirt, oil and grease contamination, paint (indications).
Surface preparation shall include a weld and base metal at a distance at least 10 mm on either side of the seam borders or, as an alternative, the entire width of the HAZ, whichever is greater.
3.2.2.4 Temperature requirements the tested surface depend on the applicable developers used and they are specified in accordance with applicable standards. As a rule, the temperature range is within the scope of +10°C up to +50°C. Outside this temperature range (for the lower and higher temperatures) special developers shall be applied (penetrants, purifiers and de-velopers) as well as corrective calibration specimens (refer to ДСТУ EN ISO 3452-5 and ДСТУ EN ISO 3452-6 for temperatures above 50°C and below 10°C, respectively, or the applicable ISO or EN standards).
3.2.2.5 Exposure time of indicator penetrant on the testing surface shall meet the specifications of a manufacturer and/or the applicable standards and be, as a rule, at least 10 min. Development time shall comply with the manufacturer's specifications and/or the applicable standards and be, as a rule, 10 to 30 min, but at least 10 min.
3.2.2.6 Record of the testing results may be performed by any of the methods or a combination thereof:
description in writing;
sketches;
photography;
video recording;
відеозапис.
3.2.3 Magnetic particle testing of welded joints.
3.2.3.1 Magnetic particle testing of welded joints shall be applied and effected in compliance with the written specifications (procedures) developed on the basis of ДСТУ EN ISO 17638 or the applicable ISO or EN standards or other international and national standards recognized by the Register.
3.2.3.2 Specifications for performing magnetic particle testing shall contain at least the following details and requirements:
requirements for the prepreparation of the surface tested;
magnetizing equipment;
sensitivity tuning method;
measuring equipment and its application;
surface conditions;
requirements and methods of demagnetization of the product after completion of the test.
3.2.3.3 The tested surface shall be cleaned and free from scale, rust, slag, dirt, oil and grease contamination, paint (indications). Furthermore, the weld surface shall be free from abrupt sinking between beads and scales as well as inadmissible undercut dimensions.
3.2.3.4 When the circular current magnetization flow through the product, care shall be taken to prevent burns from current electrodes. At the same time it is not allowed to use copper shoes (lugs) of electrical connections. Metal lugs with a low fusion point (of lead or zinc) are recommended to be used as practicable since in this case the temperature in the contact zone is not above the the metal electrical connection fusion point. It is also advised to apply shims of lead or aluminium-copper grid.
3.2.3.5 To ensure detection of imperfections of any orientation the welds shall be magnetized in about two mutually perpendicular directions with tolerances of at least 30°.
For lap joints testing of the whole surface shall be provided.
3.2.3.6 The magnetic suspension shall be applied in any manner ensuring free movement of magnetic particles on the tested surface (under testing): dry spraying, spray arc or suspension jet watering, immersion in a suspension bath. In this case a method of applying a continuous layer of wet suspension shall be used as practicable.

3.2.3.7 Examination of the tested surface shall be carried out immediately after processing it with magnetic suspension. At the control method of applied field the examination is also carried out during processing the product with magnetic suspension.

3.2.4 Radiographic testing of the welded joints.

3.2.4.1 Radiographic testing of the welded joints shall be applied and carried out in compliance with written specifications (procedures) developed on the basis of ДСТУ EN ISO 17636 or the applicable ISO or EN standards or other international and national standards recognized by the Register.

3.2.4.2 2 Specifications for performing radiographic testing shall contain at least the following details and requirements:

material of the tested product;

type of radiation source and the maximum size of the focal spot of the radiation source;

the X-ray tube voltage during X-ray examination;

X-rayed control areas penetrated radiation thickness (total thickness of the base and weld metal in the direction of the central ray of the radiation beam);

X-ray and control schemes (location and numbers of controlled areas);

the overlap of radiographs with continuous control;

type and location of the sensitivity standards;

class and testing sensitivity;

type (Class) of radiographic film and intensifying screens feature if required;

length and width of the radiographic films;

specifications for the terms of exposure;

requirements for processing radiographic films;

requirements for the optical density of exposures and conditions of their viewing (maximum brightness of the X-ray viewer illuminated field).

3.2.4.3 X-ray schemes of welded joints shall comply with international or national standards. X-ray directions in these schemes shall be as such as during X-ray examination the maximum amount of the weld deposited metal is controlled (monitored) at a minimum radiation thickness of the welded joint controlled metal. Thus where practicable X-ray examination is carried out the next but one wall.

3.2.4.4 Labelling of radiograph shots shall enable to identify where applicable: the hull number (order), section number located on the outer shell plate (starboard/portside), location (or order number of a radiograph) and the control date.

3.2.4.5 The radiation sources for radiographic inspection of welded joints, X-ray devices shall be used as well as radioactive isotopes as follows: ytterbium-169, thulium-170, selenium-75, iridium-192, cobalt-60, electron accelerators with the energy of accelerated electrons up to 12 MeV. At the same time, where possible, X-ray source shall be given priority in relation to sources of gamma radiation. Details on the application of radiation sources in accordance with ДСТУ EN ISO 17636 and the applicable ISO or EN standards are given in Tables 3.2.4.5-1, 3.2.4.5-2 and in Fig. 3.2.4.5.

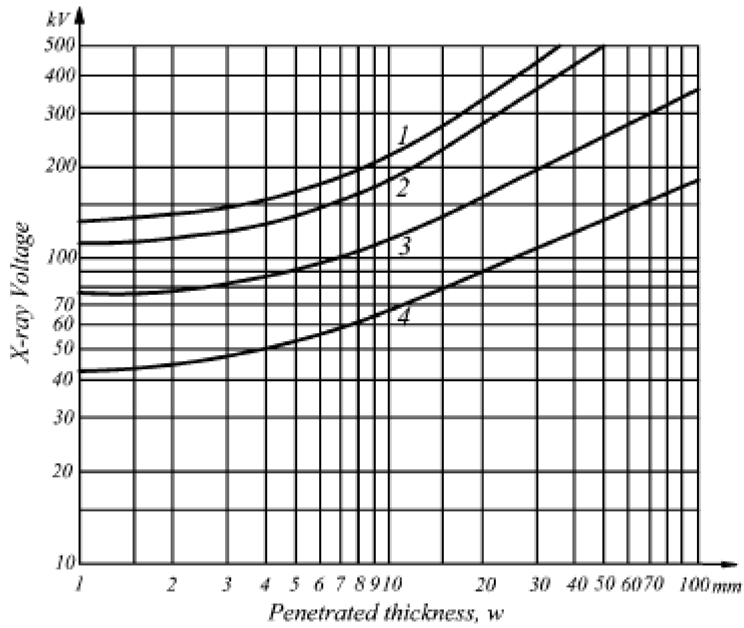


Fig.3.2.4.5 The maximum X-ray device tube voltage values depending on the penetrated thickness of the controlled metal: 1 – copper/nickel and alloys; 2 – steel; 3 – titanium and alloys; 4 – aluminium and alloys

3.2.4.6 6 The sensitivity of radiographic testing shall be determined by the image on the welded joint radiograph indicator of image quality indicator in compliance with international or national standards ДСТУ EN ISO 19232-1, ДСТУ EN ISO 19232-2 or the applicable ISO or EN standards. It is admitted to apply indicator of image quality of wire or step/hole type as well.

As a rule, indicator of image quality (the sensitivity standard) shall be installed on a tested welded joint in the centre of an X-rayed area on the radiation source side (end). By way of exception, the installation of indicator of image quality on the film side shall be applied in the following cases:

during X-ray examination of piping welded joints at the next but two walls using an image of only the adjacent to the film seam area for the joint quality assessment;

during panoramic X-ray examination of piping welded joints.

Table 3.2.4.5-1 **Penetrated thickness range for gamma ray sources for steel, copper and nickel base alloys**

Radiation source	Penetrated thickness w, mm	
	Test class A	Test class B
Tm-170	$w \leq 5$	$w \leq 5$
Yb-169[1]	$1 \leq w \leq 15$	$2 \leq w \leq 12$
Se-75[2]	$10 \leq w \leq 40$	$14 \leq w \leq 40$
Ir-192	$20 \leq w \leq 100$	$20 \leq w \leq 90$
Co-60	$40 \leq w \leq 200$	$60 \leq w \leq 150$

[1] For aluminium and titanium, the penetrated material thickness is 10 mm < w < 70 mm for control Class A and 25 mm < w < 55 for control Class B.

[2] For aluminium and titanium, the penetrated material thickness is 35 mm < w < 120 mm for Class A.

Table 3.2.4.5-2 **Penetrated thickness range for X-ray equipment with energy 1 MeV and above for steel, copper and nickel base alloys**

X-ray equipment with energy	Penetrated thickness w, mm	
	Test class A	Test class B
From 1 MeV to 4 MeV	$30 \leq w \leq 200$	$50 \leq w \leq 180$
From 4 MeV to 12 MeV	$w \geq 50$	$w \geq 80$
above 12 MeV	$w \geq 80$	$w \geq 100$

3.2.4.7 The requirements to minimum sensitivity of radiographic inspection in compliance with ДСТУ EN ISO 17636 or the applicable ISO or EN standards shall comply with Class A or B (examination level) depending on the requirements for the quality of welded joints and they are specified as per ДСТУ EN ISO 10675-1 or the applicable ISO or EN standards, Table 3.4.1.4.

The control sensitivity values complying with Classes A and B according to ДСТУ EN ISO 17636 or the applicable ISO or EN standards for wire-type indicator of image quality are shown in Tables 3.2.4.7-1÷3.2.4.7-3.

3.2.4.8 Geometric unsharpness of imperfections of images in radiographs shall not exceed one half of the minimum testing sensitivity according to **3.3.4.7**.

3.2.4.9 Length of X-rayed flat cells weld areas per an exposure and the number of exposures(areas) during X-ray of piping welded joints shall be such that the ratio of radiation thickness of X-rayed metal at the inspected areas edges and centre shall not exceed 1,2 under Class A control and 1,1 under Class B control. In this case the optical density values at the radiograph edges and in the centre shall not go beyond the limits of **3.2.4.11**.

3.2.4.10 Types of radiographic films and relevant intensifying screens shall comply with the applicable international or national standards (ДСТУ EN ISO 17636 or the applicable ISO or EN standards).

3.2.4.11 The optical density of radiographs shall be at least 2.0 at Class A control and at least 2,.3 at Class B control. The maximum value of the Image optical density is determined by the characteristics of the applied X-ray viewers and it is 4,0 for the relevant X-ray viewers of **3.2.4.12**.

3.2.4.12 To interpret the welded joints radiographs X-ray viewers shall be used with adjustable size and brightness of the illuminated field in accordance with ДСТУ EN 25580 or the international standards, such as EN 25580 or ISO 5580.

3.2.4.13 Radiographic testing of the welded joints with the use of digital detectors.

3.2.4.13.1 The radiographic testing of the welded joints with the use of digital detectors shall be used and implemented according to the written specifications (procedures) developed on the basis of the requirements of ДСТУ EN ISO 17636-2 or the applicable ISO or EN standards or other international and national standards recognized by the Register.

Table 3.2.4.7-1 **The minimum sensitivity of radiographic inspection for flat components and during X-ray of piping welded joints at the next but one wall (indicator of image quality from the radiation source side) for X-ray devices and electron accelerators[1]**

Test sensitivity, mm	Penetrated thickness w, mm	
	Test class A	Test class B
1	2	3
0,050	–	$0 < w \leq 1{,}5$
0,063	$0 < w \leq 1{,}2$	$1{,}5 < w \leq 2{,}5$
0,080	$1{,}2 < w \leq 2$	$2{,}5 < w \leq 4$
0.100	$2 < w \leq 3{,}5$	$4 < w \leq 6$
0,125	$3{,}5 < w \leq 5$	$6 < w \leq 8$
0,16	$5< w \leq 7$	$8 < w \leq 12$
0,20	$7 < w \leq 10$	$12 < w \leq 20$
0,25	$10 < w \leq 15$	$20 < w \leq 30$
0,32	$15 < w \leq 25$	$30 < w \leq 35$
0,40	$25 < w \leq 32$	$35 < w \leq 45$
0,50	$32 < w \leq 40$	$45 < w \leq 65$
0,63	$40 < w \leq 55$	$65 < w \leq 120$
0,80	$55 < w \leq 85$	$120 < w \leq 200$
1,0	$85 < w \leq 150$	$200 < w \leq 350$
1,25	$150 < w \leq 250$	$350 < w$
1,60	$250 < w$	–

[1] During X-ray of welded joints by gamma radiation (Iridium-192) the values given in Table shall be lowered down (decreased) (reduce sensitivity):
Class A control:
two steps lower for thicknesses over 10 up to 24 mm inclusive;
two steps lower for thicknesses over 24 up to 30 mm inclusive;
Class B control:
a step lower for thicknesses over 12 up to 40 mm inclusive.

Table 3.2.4.7-2 **The minimum sensitivity of radiographic inspection during X-ray of piping welded joints at the next but two walls (indicator of image quality from the radiation source side) during pano-ramic X-ray examination of piping welded joints for X-ray devices and electron accelerators (indicator of image quality on the film side)[1]**

Test sensitivity, mm	Penetrated thickness w, mm	
	Test class A	Test class B
1	2	3
0,050	–	$0 < w \leq 1{,}5$
0,063	$0 < w \leq 1{,}2$	$1{,}5 < w \leq 2{,}5$
0,080	$1{,}2 < w \leq 2$	$2{,}5 < w \leq 4$
0.100	$2 < w \leq 3{,}5$	$4 < w \leq 6$
0,125	$3{,}5 < w \leq 5$	$6 < w \leq 8$
0,16	$5 < w \leq 7$	$8 < w \leq 15$
0,20	$7 < w \leq 12$	$15 < w \leq 25$
0,25	$12 < w \leq 18$	$25 < w \leq 38$
0,32	$18 < w \leq 30$	$38 < w \leq 45$
0,40	$30 < w \leq 40$	$45 < w \leq 55$
0,50	$40 < w \leq 50$	$55 < w \leq 70$
0,63	$50 < w \leq 60$	$70 < w \leq 100$
0,80	$60 < w \leq 85$	$100 < w \leq 170$
1,0	$85 < w \leq 120$	$170 < w \leq 250$
1,25	$120 < w \leq 220$	$250 < w$
1,60	$220 < w \leq 380$	–
2,00	$380 < w$	–

[1] Refer to Footnote to Table 3.2.4.7-1

Table 3.2.4.7-3 **The minimum sensitivity of radiographic inspection during X-ray of piping welded joints at the next but two walls (indicator of image quality on the film side) for X-ray devices and electron accelerators[1]**

Test sensitivity, mm	Penetrated thickness w, mm	
	Test class A	Test class B
1	2	3
0,050	–	$0 < w \leq 1{,}5$
0,063	$0 < w \leq 1{,}2$	$1{,}5 < w \leq 2{,}5$
0,080	$1{,}2 < w \leq 2$	$2{,}5 < w \leq 4$
0.100	$2 < w \leq 3{,}5$	$4 < w \leq 6$
0,125	$3{,}5 < w \leq 5$	$6 < w \leq 12$
0,16	$5 < w \leq 10$	$12 < w \leq 18$
0,20	$10 < w \leq 15$	$18 < w \leq 30$
0,25	$15 < w \leq 22$	$30 < w \leq 45$
0,32	$22 < w \leq 38$	$45 < w \leq 55$
0,40	$38 < w \leq 48$	$55 < w \leq 70$
0,50	$48 < w \leq 60$	$70 < w \leq 100$
0,63	$60 < w \leq 85$	$100 < w \leq 180$
0,80	$85 < w \leq 125$	$180 < w \leq 300$
1,0	$125 < w \leq 225$	$300 < w$
1,25	$225 < w \leq 375$	–
1,60	$375 < w$	–

[1] Refer to Footnote to Table 3.2.4.7-1

3.2.4.13.2 The radiographic testing of the welded joints with the use of digital detectors may be used for the rolled sheets and plates and pipes for detection of the defects with computed radiography (CR) or radiography with the use of digital detector array (DDA).

Computed radiography (CR) is a system with a phosphor imaging plate (IP). The complete system comprises a phosphor imaging plate (IP) and a respective reading device (scanner or reader), which converts information from the IP into a digital image.

Digital detector array (DDA) system is a system comprising an electronic device converting the ionization or penetrating radiation into a set of separate analogue signals, which are later digitized and sent to the computer to be displayed as a digital image corresponding to distribution of the radiant energy transmitted to the device's receiving surface. The digital detectors provide a digital greyscale image with a grey value (GV), which can be decoded and assessed with a computer.

Grey value (GV) is a numeric value of pixel on the digital image.

3.2.4.13.3 The requirements for minimum sensitivity of the radiographic testing with the use of digital detectors corresponding to classes A and B shall be equivalent to those given in Tables 3.2.4.7-1, 3.2.4.7-2 and 3.2.4.7-3 for IR of wire type for the film radiography.

3.2.5 Ultrasonic testing of welded joints.

3.2.5.1 Ultrasonic testing of welded joints shall be applied and carried out in compliance with written specifications (procedures) developed on the basis of ДСТУ EN ISO 17640 or the applicable ISO or EN standards or other international and national standards recognized by the Register.

3.2.5.2 Ultrasonic testing of welded joints is carried out on the surface after rolling, shot-blasting or machining. The surface shall be free of dents and irregularities, metal spatter, soot, scale disbondment, rust and paint shall be removed from it.

Surface waviness shall provide a gap between the surface of scanning and contact surface of converters and transformers of at least 0,5 mm. If necessary, an additional surface machining shall be performed to meet this requirement. Local surfaced imperfections causing a gap increase below the contact surface up to 1 mm may be permitted only if additional scanning of this area/section is provided by the converter at a different entry angle.

3.2.5.3 Sizes of areas into which a welded joint is divided under control, and their marking-out shall comply with those accepted for radiographic control if possible.

Circumferential welded joints of pipes are divided into areas by analogy with the clock dial customizing if possible to the working environment progress direction.

3.2.5.4 Deposited weld metal, merging zone and heat affected zone shall be subject to ultrasonic testing. The base metal layer of width at least 10 mm, adjacent to the heat affected zone, shall be included in the controlled area and evaluated according to the criteria specified for the joint.

3.2.5.5 Specification for carrying out ultrasonic testing shall contain the following information and requirements at a minimum:

identification particulars on a controlled product:

the hull number (order), section number located on the outer shell plate (starboard/portside), location (or order numbers of areas under control, drawings, etc.);

types (marks) of base material and welding consumables;

type of a welding consumable (rolled products, forgings, castings, etc.);

welding process;

product manufacturing stage in which control is performed (either before or after heat treatment, fully or partly welded seam) including the required heating time after the preceding control operation;

drawing of a controlled welded joint indicating edge preparations of the joint thickness, available weld reinforcement and its width, geometrical shape of input surface and roughness requirements;

level of control including sonic scheme showing scanning areas for each of the passageways, input PEC angles as well as the requirements for the identification of longitudinal and transverse imperfections, with reference to the relevant normative and technical document (standards, rules);

type of a used non-destructive testing (NDT) instrument and converters (including frequency, angle of entry, the size and shape of the piezoelectric element);

method for setting the sensitivity reference level indicating the used standard samples (or the manufacturer's (firm's) standard samples);

controlled and reported sensitivity levels as well as the requirements to an acceptable level of assessment of the imperfections identified with reference to the applicable standard, and, if necessary, additional requirements;

necessity and a way of adjusting the sensitivity taking into account the input surface state of ultrasonic oscillations;

the personnel's qualifications as per national or international standards.

3.2.5.6 To carry out ultrasonic testing the following shall be applied:

ultrasonic flaw pulse detectors of general purpose with piezoelectric transducers (probes) complying with the requirements of ДСТУ EN 12668 or the international and national standards (e.g., EN 12668 - all parts) and with technical characteristics as per the requirements of these rules and specifications to carry out monitoring of specific objects;

PEC straight dual, straight single-dual, inclined dual and single-dual search units providing a frequency range of at least 2 to 6 MHz;

national or international standard specimens (gauge blocks) to check the basic control characteristics and settings of working modes of non-destructive testing (NDT) instruments (e.g., specimens of K-1 and K-2 of ДСТУ EN ISO 2400 and ДСТУ EN ISO 7963 or the applicable ISO or EN standards);

standard samples of the firm (gauge blocks) to set the reference sensitivity level of control that meet the requirements of the applicable standards;

devices for control of the mirror-like echo method as per schemes "straddle" and "tandem";

devices for stabilizing the acoustic coupling (bearings, nozzles) under the control by curved surfaces;

auxiliary arrangements and devices for evaluating the surface roughness and waviness, compliance with scanning parameters and measurement of parameters of the imperfections revealed;

DAC (distance-amplitude-curve) or DGS (distance gain size) of a diagram or scale;

specialized non-standard probes;

means of providing ultrasonic contact in accordance with the requirements of the applicable standards (e.g., ДСТУ EN ISO 16810 or the applicable ISO or EN standards).

3.2.5.7 Inclined PEC operating on transverse waves shall provide input angles from 35° till 75° ((as a rule, 45°, 60° and 70°). In the case where the sonic scheme involves the use of PECs with two or more entry/input angles, the difference between the nominal input angles shall be at least 10°.

Admission to the angle shall be at least ±2°.

3.2.5.8 Each converter shall have an identification number, files or other document, which shall also state its type, frequency, angle of entry (into steel), form and geometrical dimensions of piezoelectric elements.

3.2.5.9 When monitoring cylindrical and spherical surfaces, the gap between the scanning surface and the contact surface of PEC shall not exceed 0,5 mm. This requirement is usually performed provided that $D \geq 15b$, where D is a diameter of the product in mm, b - a linear size of PEC contact surface in the control plane. If this requirement is not complied with, adaptation of the PEC contact surface is required to the product shape or ointment or application of coupling gaskets or supports fixing its position.

3.2.5.10 Equipment for ultrasonic testing shall provide the gain control setting (playing of standard level of sensitivity control) upon increment (maximum pitch) of at least 2 dB within the scope of at least 60 dB.

3.2.5.11 Prior to ultrasonic testing the basic parameters shall be checked out which affect its results. The check shall include the identification of:

the angle of an ultrasonic beam entering into the metal;

position of the exit point of the beam and inclined PEC boom;

dead area;

resolution capability on the beam;

deviation of the acoustic axis of straight and inclined PEC off the nominal direction.

Checks are carried out according to a firm's written procedure performing control.

3.2.5.12 In the case when estimation is performed in compliance with the admissible assessment levels of the revealed imperfections based on the length and amplitude of the echo signal, such as ДСТУ EN ISO 11666 or the applicable ISO or EN standards, for initial testing the frequency shall be selected if possible closer to the lower limit within the recommended range of 2 to 6 MHz. Higher speed values closer to the upper limit of the recommended range, can be used to improve the control resolution capability range in the case it is necessary to assess the readings for compliance with the acceptable levels based on the characteristics of imperfections, such as ДСТУ EN ISO 23279 or the applicable ISO or EN standards.

Frequencies within 1 MHz may be used for testing products with a longer sound channel where the signal attenuation level by the material is above average.

3.2.5.13 In accordance with the standards ДСТУ EN ISO 17640 and ДСТУ EN ISO 11666 or the applicable ISO or EN standards during ultrasonic testing the following four levels of sensitivity and assessment of results are applied:

reference level is a sensitivity level used to set the initial level of the reference echo amplitudes;

evaluation level is a sensitivity level according to which or while exceeding it the assessment of the revealed imperfections shall be carried out (refer to Table 3.4.6.1);

recording level is a sensitivity level defined as complying with the admissible level of assessment minus 4 dB;

acceptance level is a level of assessment of the identified imperfections in compliance with the requirements for acceptance of products (refer to Table 3.4.6.1).

3.2.5.14 In accordance with ДСТУ EN ISO 17640 or the applicable ISO or EN standards for setting the reference level of ultrasonic testing sensitivity one of the methods listed may be used:

method 1 — reference level is a DAC (distance-amplitude curve) chart drawn up using standard specimens of the firm with the side drilled hole of 3 mm diameter (refer to Table 3.2.5.14-1);

method 2 — to set the reference level for the longitudinal and transverse waves DGS (distance gain size) charts or scales are used built using standard specimens with flatbottom DSR — disc shaped reflectors. Reference levels of sensitivity in accordance with ДСТУ EN ISO 17640 or the applicable ISO or EN standards for inclined and straight PEC are shown in Table 3.2.5.14-2 and 3.2.5.14-3;

method 3 — – for the reference level DAC chart is taken drawn up with the use of the firm's reference materials (standard specimens) with a rectangular notch 1 mm in width and 1 mm in depth. This method of sensitivity settings can be used for inclined PEC with an input angle of over 70° and a range of thicknesses of 8 mm≤ t <15mm;

method 4 — using sonic testing schemes "tandem" as a reference level signal is received from the flatbottomed hole with a diameter of 6 mm (for all thicknesses) perpendicular to the surface scanned. This method only applies to the loop input angle of 45° and thickness t ≥15mm.

Table 3.2.5.14-1 **The requirement to the size of the firm's standard specimens (gauge blocks) to draw u DAC charts**

The material thickness to be inspected, mm	Standard specimen thickness, mm	Hole diameter, mm	Distance from the hole to one of the surfaces, mm
$10 < t \leq 50$	40 or *t*	Ø3 ±0,2	*t*/2 and *t*/4 Additional holes are permitted and recommended
$50 < t \leq 100$	75 or *t*		
$100 < t \leq 150$	125 or *t*	Ø6 ±0,2	
$150 < t \leq 200$	175 або *t*		
$200 < t \leq 250$	225 or or *t*		
$t > 250$	275 or *t*		

Notes:

1. The calibration (gauge) block (arrangement) shall be made of actually tested material, it shall have approved dimensions and be checked in accordance with the established procedure.

2. In the case ultrasonic testing is used to control rolled steel structures as delivered CR (controlled rolling) or TM (thermomechanical rolling), relevant gauge blocks (arrangements) shall be made perpendicular and parallel to the rolling direction. Rolling direction shall be clearly identified both on the gauge blocks and on a controlled product (item).

3. The use of reference materials for the control of large thicknesses with a side hole diameter of 6 mm is recommended as it is not regulated by ДСТУ EN ISO 17640 or the applicable ISO or EN standards.

Table 3.2.5.14-2 **Reference levels for acceptance levels 2 and 3 for technique 2 using angle beam scanning with transverse waves (method 2 of ДСТУ EN ISO 17640 or the applicable ISO or EN standards)**

Nominal probe frequency, MHz	Thickness of parent metal, mm					
	$8 \leq t < 15$		$15 \leq t < 40$		$40 \leq t < 100$	
	AL 2	AL 3	AL 2	AL 3	AL 2	AL 3
From 1,5 to 2,5	–	–	D_{DSR} = 2,5mm	D_{DSR} = 2,5mm	D_{DSR} = 3,0mm	D_{DSR} = 3,0mm
Від 3 до 5	D_{DSR} = 1,5mm	D_{DSR} = 1,5mm	D_{DSR} = 2,0mm	D_{DSR} = 2,0mm	D_{DSR} = 3,0mm	D_{DSR} = 3,0mm

D_{DSR} is the diameter of a flat-bottomed DSR – disc shaped reflector

AL2 and AL3 are admissible imperfections acceptance levels according to ДСТУ EN ISO 11666 or the applicable ISO or EN standards.

Table 3.2.5.14-3 **Reference levels for acceptance levels 2 and 3 for technique 2 using straight beam scanning with longitudinal waves (method 2 of ДСТУ EN ISO 17640 or the applicable ISO or EN standards)**

Nominal probe frequency, MHz	Thickness of parent metal, mm					
	$8 \leq t < 15$		$15 \leq t < 40$		$40 \leq t < 100$	
	AL 2	AL 3	AL 2	AL 3	AL 2	AL 3
1,5 to 2,5	–	–	D_{DSR} = 2,5 mm	D_{DSR} = 2,5 mm	D_{DSR} = 3,0mm	D_{DSR} = 3,0 mm
3 to 5	D_{DSR} = 2,0mm	D_{DSR} = 2,0 mm	D_{DSR} = 2,0 mm	D_{DSR} = 2,0 mm	D_{DSR} = 3,0mm	D_{DSR} = 3,0 mm

D_{DSR} - is the diameter of a flat-bottomed DSR – disc shaped reflector.

AL 2, AL 3 are admissible imperfections acceptance levels according to ДСТУ EN ISO 11666 or the applicable ISO or EN standards.

3.2.5.15 Weld test scheme on the quantity of scanning directions and scan camera angles applied (PEC inclined input angle) shall comply with the applicable international or national standards, such as ДСТУ EN ISO 17640 or the applicable ISO or EN standards. Thus for welds of increased and high steel strength irrespective of applicable acceptable level, as well as for an applicable acceptable level "B" as per ISO 5217 (procedure and testing level is not lower than "B" ISO ДСТУ EN ISO 17640 or the applicable ISO or EN standards, (procedure and testing level is not lower than "B" ДСТУ EN ISO 11666 or the applicable ISO or EN standards, acceptance level 2, refer to Table 3.4.1.4) it is obligatory to perform sounding (scanning) to detect transverse imperfections (T-scan).

Note. If the manufacturer is able to provide documentary evidence of indisposition for cracking of the applied materials used and welding process, scanning can not be implemented for high strength steels of categories A/F 40 and lower in thicknesses up to 40 mm inclusive to detect transverse imperfections (T-scan) at the control level on acceptance level 3 ДСТУ EN ISO 11666 or the applicable ISO or EN standards.

3.2.5.16 At the sensitivity setting possible difference in roughness and waviness of a specimen surface used to set the sensitivity, and the weld surface of a controlled weld in the scanning area shall be taken into account. The necessity and method of adjusting the sensitivity shall be specified in a written procedure of a testing firm, and the actual correction value - in an appropriate specification of inspection in accordance with the instructions set out below.

If the difference in sensitivity between the firm's standard specimen and the testing surface is less than 2 dB, sensitivity correction is not required.

If the difference in sensitivity between the firm's standard specimen and the testing surface is over 2 dB, but less than 12 dB, it shall be appropriately balanced.

If the difference in sensitivity between the firm's standard specimen and the testing surface is over 12 dB, the cause shall be found out and measures for further preparation of a scanned surface shall be taken if possible.

When the obvious reasons for high differences in sensitivity are not seen, degradation of a signal shall be measured from different places of a test item, and if it is found to be very significant, the appropriate corrective actions shall be considered.

Methods to correct sensitivity shall comply with the relevant standards (e.g., ДСТУ EN 12668-1:2015 or the applicable EN standard).

3.2.5.17 When testing circumferential piping welded joints by a single reflected beam adjustable for planeparallel specimens or reference signals received with a direct ray as well as at the direct PEC control the loss of signal amplitude shall be considered on the inner cylindrical surface of the weld HAZ. Method of correction reference shall be specified in a written procedure of a testing firm, and the actual correction value - in an appropriate specification of inspection.

3.2.5.18 Before ultrasonic testing of the weld straight PEC control of base metal shall be made across the width of the scanning surface for detection and reporting of imperfections that may affect the ability to control the weld by the inclined PEC. As a result of control of the base metal, if required, specifications to perform ultrasonic testing shall be corrected and with the technical inability to control weld run in full - alternative methods of non-destructive testing (e.g., radiographic) are provided that shall be noted in the test report.

Note. The requirement to monitor the continuity of the base metal can also be confirmed by previous examinations (for example, during the production and control of the base metal).

3.2.5.19 The sensitivity of the PEC flaw detector shall be checked prior to the start of monitoring, after work breaks and completing testing, and periodically every 60 minutes during testing in accordance with the instructions set out below:

If the sensitivity is not changed for more than 4 dB, prior to continuation of testing equipment settingup shall be adjusted.

If the sensitivity is reduced by more than 4 dB, the setting shall be corrected, and the control of welded joints made since the last adjustment correction shall be carried out completely again.

If the sensitivity is increased by more than 4 dB, the setting shall be adjusted, and all the detected and assessed "unfit" imperfections shall be monitored and reassessed.

3.2.6 Report on the results of non-destructive testing of welded joints.

3.2.6.1 Reports on non-destructive testing of welded joints shall be prepared by the manufacturer of welded structures and submitted to the RS surveyor.

3.2.6.2 Reports on non-destructive testing of welded joints shall contain general information for all control methods:

date of testing;

surname, name, qualifications level and of the person's signature performing the test;

identification of the tested item;

identification of tested welds;

category (type) of material, type of connection (joint), thickness of the base metal, method (procedure) of welding;

procedures and testing level as well as an acceptance level of the revealed discrepancies of welds;

applicable standards and rules;

applicable test equipment and devices;

restrictions on testing, testing conditions and temperature;

test results with reference to the relevant criteria, location and size of the imperfections to be considered;

assessment of testing results as per the alternative system of "fit-unfit"("acceptance - nonacceptance");

quantity of corrections if one area of control was under repairs more than twice.

3.2.6.3 For dye penetrant control methods report on the tests shall include the following additional special items:

type of indicator penetrant;

applicable purifier and developer;

drying time (conditioning before removal) of indicator penetrant;

development time.

3.2.6.4 For magnetic particle inspection report on tests shall include the following special items:

type of magnetization;

total magnetic intensity;

view of a magnetic suspension (magnetic ink);

conditions for examination of the tested surface;

product demagnetization procedure at the end of control if required.

3.2.6.5 For radiographic testing method report on tests shall include the following special items:

type of radiation source and the maximum size of the focal spot of the radiation source;

during X-ray examination voltage on a tube of an X-ray apparatus;

type of a radiographic film;

type of intensifying screens;

X-raying scheme, exposure time and distance from the focal spot of the radiation source to the radiographic film;

control sensitivity, type and location of an indicator of image quality;

optical density of the image;

geometric blur images.

3.2.6.6 For ultrasonic testing method report on tests shall include the following special items:

information on the used control instruments (type, model and serial number of the flaw detector,

type, frequency, PEC angle of entry and registration number, couplant);

setting method and level of sensitivity;

correction method and actual value of the sensitivity allowance;

type and designations of used standard specimens (sample units) and standard specimens used for equipment settings;

type of the return (echo) signal used to detect imperfections.

3.3 SCOPE OF NON-DESTRUCTIVE TESTING

3.3.1 The scope of non-destructive testing of hull welds in the inspection plan approved by the Register shall be determined in accordance with Table 3.3.1.

The number of weld lengths in shell plating for 0,4*L* amidships to undergo radiographic or ultrasonic testing shall be determined by the following formula

$$N = \frac{L(B+D)}{45}T\,, \qquad (3.3.1)$$

where: N – number of controlled weld lengths;

L, B, D – length, breadth and depth of ship, in m;

T – factor depending on ship type and manufacturing conditions and determined at the approval of the inspection plan. Following are the maximum values of the factor T for various ship types:

up to 0,7 for ships having the length $L < 60$ m;

up to 0,9 for ships having the length $60 \le L < 80$ m;

up to 1,1 for dry cargo ships, bulk carriers, special purpose ships, supply vessels, fishing vessels and ro-ro ships;

up to 1,2 for ships for carriage of heavy bulk cargoes, ore carriers, ore or oil carriers and oil or bulk dry cargo carriers;

up to 1,3 for oil tankers and container ships.

For ships not listed above, the factor T is determined in agreement with the Register.

It is assumed in the calculation that the controlled weld length is 0,5 m.

The scope of the non-destructive testing of welded joints using the radiographic or ultrasonic testing for type ships (when applying the manufacture of new products, and also during repair, modification and conversion) may be increased as compared to the values determined by Formula (3.3.1) and given in Table 3.3.1 by the Register or designer's demand.

Where structural elements are welded into a rigid contour (cutouts with the ratio of the minimum dimension to a shell thickness of 60 and less), the fully penetrated butt and tee-joints of the hull plating shall be checked along their entire length, and the remaining structures, to the extent of at least 20 % of their length using the radiographic or ultrasonic testing.

The radiographic or ultrasonic testing of the welded joints of the structures subjected to treatment under pressure (bending, stamping, etc.) shall be executed along the entire length of the welded joints of these structures after treatment under pressure. When the structures are subjected to heat treatment after treatment under pressure, the radiographic or ultrasonic testing shall be carried out thereafter.

3.3.2 The welded joints of steam boilers, pressure vessels and heat exchangers shall be subjected to non-destructive testing within the scope specified in Table 3.3.2 depending on the class of structure (refer to **1.3.1.2**, Part X "Boilers, Heat Exchangers and Pressure Vessels").

Table 3.3.1

Nos.	Test location	Type of welded joint	Scope of testing		
			visual testing [1,2], %	radiographic and ultrasonic testing, number of radiographs	
			Ship area		
			fore-and-af	within 0,4L amidships	outside 0,4L amidships
1	2	3	4	5	6
1	Plating butts (mainly intersections with seams): strength deck outside hatch line sheerstrake (in area 0,1D below strength deck) bilges (in area 0,1D above bottom) bottom Butts: of hatch side coamings of thickened deck plates in way of hatchway corners and at ends of superstructures of longitudinal bulkheads (in area 0,1D below strength deck)	Butt weld	100	About 0,60N	Random[3]
2	Hull plating butts - remaining[4] (mainly intersections with seams)	Butt weld	100	About 0,20N	Random[3]
3	Hull plating seams	Butt weld	100	About 0,20N	Random[3]
4	Welded joints of longitudinal stiffeners (in longitudinal framing): of strength deck outside hatch line of sheerstrake (in area 0,1D below strength deck) of bilge (in area 0,1D above bottom) of longitudinal bulkheads (in area 0,1D below strength deck) of bottom	Butt weld	100	1 radiograph per 10 butts (mainly mounting butts)	Random[3]
5	Welded joints of longitudinal stiffeners (in longitudinal framing) in other places not specified under item 4	Butt weld	100	1 radiograph per 10 butts (mainly mounting butts)	Random[3]

6	Welded joints of transverse stiffeners (in transverse framing)	Butt weld	100	1 radiograph per 10 butts	Random[3]
7	Welded joints on sternframe	Butt weld	100	-	50 % of hull plating welded joints in way of sterntube[5]
8	Welded joints between deck stringer and sheerstrake[6] (in way of intersection with butt welds)	Fillet weld or T-joint, full penetration	100	4 controlled lengths along the 1st plate	Random[3]
9	Welded joints on the welded stem	Butt, fillet weld or T-joint, full penetration	100	-	50 % of hull plating welded joints with stem plates, 50 % of welded joints of stem plates

[1] Where there are doubts as to the results of visual testing, penetrant or magnetic particle testing may be carried out.
[2] All welded joints (including those not specified in the table) shall undergo testing.
[3] The number of weld lengths undergoing testing shall be up to 20 % of the lengths specified for the area 0,4L amidships.
[4] Where ice strengthened, the ice belt butts shall mainly be tested.
[5] Intersections between seams and butts shall be tested.
[6] Ultrasonic testing is recommended.

Table 3.3.2

Class of structure (boilers, pressure vessels and heat exchangers)	Type of welded joint	Scope of welded joint testing as percentage of total weld length	
		visual and inspection[1]	radiographic or ultrasonic
I	Longitudinal	100	100
II			25
III			On agreement with the Register
I	Circular		50
II			25
III			On agreement with the Register

[1] In case of doubts in the results of visual testing, penetrant or magnetic particle testing may be carried out.

3.3.3 The welded joints of piping, depending on their class indicated in Table 1.3.2, Part VIII "Systems and Piping", shall be subjected to non-destructive testing within the scope specified in Table 3.3.3.

3.3.4 Besides the structures specified in Tables 3.3.1 to 3.3.3, such elements of machinery and gear as joints in cargo masts and posts, etc. are subject to non-destructive testing. The controlled weld lengths in these structures shall be established upon agreement with the surveyor.

3.3.5 5 The surveyor may determine a distribution of non-destructive testing weld lengths differing from that specified in the approved inspection plan depending on the particular conditions, under which welding is carried out.

Table 3.3.3

Class of piping	Outer diameter of pipe, mm	Scope of welded joint testing as percentage of total weld length	
		visual and inspection[1]	radiographic or ultrasonic
I	≤ 75	100	10[2]
	> 75		100
II	≤ 100		Random
	> 100		10[2]
III	Any		Random

[1] In case of doubts in the results of visual testing, dye penetrant or magnetic particle testing may be carried out.
[2] But not less than one welded joint made by a particular welder.

3.3.6 The works shall determine, on the basis of radiographic and ultrasonic testing, the percentage of welded joint defects not less than once in six months and report the results to the Register.

The percentage of defects in welded joints shall be determined by the following formula

$$K = 100 l/s, \qquad (3.3.6)$$

where: K – welded joint defect percentage;

l – total length of controlled welds found unsatisfactory, in m;

s – total weld length controlled, in m.

If the percentage of defects is more than 5, the Register is entitled to require, for every per cent of rejected welds exceeding this value, an increase in the number of controlled weld lengths by 10 %.

The number of controlled weld lengths may be reduced if the surveyor finds the general standard of welding operations satisfactory.

3.3.7 For the purpose of conversion and repair of ships and craft, the number of controlled weld lengths is determined by the Register proceeding from the scope of welding and the importance of structures bearing the above in mind.

3.4 ASSESSMENT OF WELDED JOINT QUALITY IN HULL STRUCTURAL STEEL.

3.4.1 General.

3.4.1.1 Ultrasonic method of welded joints testing shall be carried out in compliance with quality levels of the relevant requirements of ДСТУ ISO 5817 or the applicable ISO standard or other international and national standards recognized by the Register.

3.4.1.2 Quality level requirements in compliance with ДСТУ ISO 5817 or the applicable ISO standard, for the hull structural steel shall be assigned in accordance with the instructions of Table 3.4.1.2.

3.4.1.3 Quality level requirements in compliance with ДСТУ ISO 5817 or the applicable ISO standard, for the hull structural steel shall be assigned in accordance with the instructions of Table 3.4.1.3.

Table 3.4.1.2

Structural member category[1]	Type of welded joints	Minimum quality level in compliance with ДСТУ ISO 5817 (ISO 5817) for ships with the following length			
		$L \leq 250$ m		$L > 250$ m	
		Within 0,4L amidships	Without 0,4L amidships[2]	Within 0,4L amidships	Without 0,4L amidships[2]
III	Butt joints	B	B	B	B
	Fillet joints, T-joints and cruciform joints with full penetration	B	B	B	B
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	C	C	B	C
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	C	C	C
II	Butt joints	B	C	B	C
	Fillet joints, T-joints and cruciform joints with full penetration	C	C		C
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	C	D	C	C
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	D	C	D
I	Butt joints	C	C	C	C
	Fillet joints, T-joints and cruciform joints with full penetration	C	C	C	C
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	C	D	C	D
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	D	C	D

[1] In compliance with **1.2.3.7**, Part II "Hull".

[2] For welded stems of icebreakers and ice class ships, the minimum quality level shall be equal to B.

Table 3.4.1.3

Class of structure[1]	Type of welded joint	Minimum quality level in compliance with ДСТУ ISO 5817 (ISO 5817)	
		Boilers and heat exchangers	Piping
1	2	3	4
III	Butt joints	B	B
	Fillet joints, T-joints and cruciform joints with full penetration	B	B

	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	B	B
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	C
II	Butt joints	B	B
	Fillet joints, T-joints and cruciform joints with full penetration	B	B
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	C	C
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	C
I	Butt joints	B	B
	Fillet joints, T-joints and cruciform joints with full penetration	C	C
	Fillet joints, T-joints and cruciform joints with beveling and lack of structural fusion	C	C
	Fillet joints, T-joints and cruciform joints made by a fillet weld without beveling	C	C

[1] In compliance with **1.3.2**, Part VIII "Systems and Piping" and **1.3.1.2**, Part X "Boilers, Heat Exchangers and Pressure vessels".

3.4.1.4 For specific non-destructive testing procedure acceptable levels of imperfection acceptance in accordance with the established quality levels as per ДСТУ ISO 5817 or the applicable ISO standard, as well as the requirements for the class and procedure of control are specified by ДСТУ EN ISO 17635 or the applicable ISO or EN standards and as a rule they shall be assigned in accordance with Table 3.4.1.4.

3.4.1.5 Assessment of the welded joints quality within each level of assessment of imperfections shall be performed as per an alternative system of "fit - unfit" ("acceptance - non-acceptance") applying assessment criteria, according to **3.4.2, 3.4.3, 3.4.4, 3.4.5** and **3.4.6**.

Table 3.4.1.4

Quality level in accordance with ДСТУ ISO 5817	Radiographic testing		Ultrasonic (US) testing[1]		Visual and Inspection testing		Magnetic Particle testing		Penetrant testing	
	Testing techniques and classes in accordance with ДСТУ EN ISO 17636	Acceptance levels[2] in accordance with ДСТУ EN ISO 17636-1	Testing technique and level in accordance with ISO ДСТУ EN ISO 17640	Acceptance level[2] in accordance with ДСТУ EN ISO 11666	Testing technique and level in accordance with ДСТУ EN ISO 17636	Acceptance level[2, 3]	Testing techniques and classes in accordance with ДСТУ EN ISO 17638	Acceptance level[2] in accordance with ДСТУ EN ISO 23278	Testing techniques and classes in accordance with ДСТУ EN ISO 3452	Acceptance level[2] in accordance with ДСТУ EN ISO 23277
1	2	3	4	5	6	7	8	9	10	11
B	B	1	at least B	2	LQ[7]	B	LQ[7]	2×[6]	LQ[7]	2×[6]
C	B[4]	2	at least A	3		C		2×[6]		2×[6]
D	A	3	at least A[5]	3[5]		D		3×[6]		3×[6]

Note. Along with the specified ДСТУ standards, the appropriate ISO and EN standards may be applied.

[1] In case the definition of the imperfections character is required ДСТУ EN ISO 23279 is applied.

[2] Acceptance level is expressed in quality grades.

[3] Acceptance level for visual and inspection testing are incompliance with Quality Levels in accordance with ДСТУ ISO 5817.

[4] The minimum number of exposure for circumferential weld testing may correspond to the requirements of class A of ДСТУ EN ISO 17636.

[5] UT in accordance with ISO 11666 for Level Quality D (ДСТУ ISO 5817) is not recommended, but upon its

application it can be defined with the same requirements as Quality level C (ДСТУ ISO 5817).

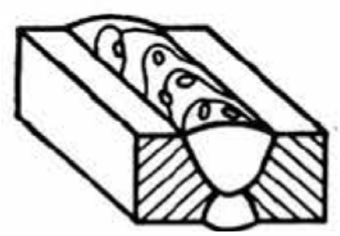
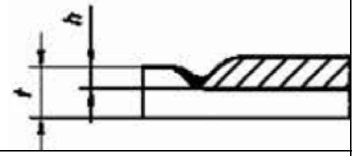
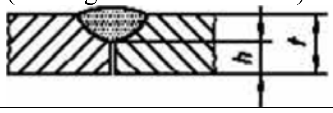
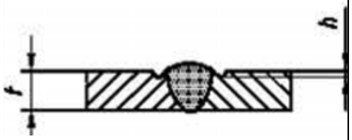
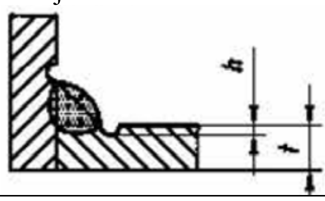
[6] Quality levels 2 and 3 can have index «6» which designates all imperfections above 25 mm and are not permitted;

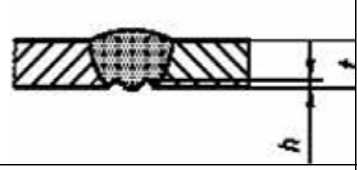
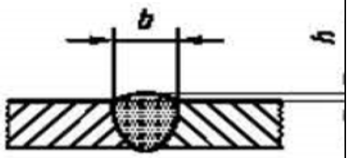
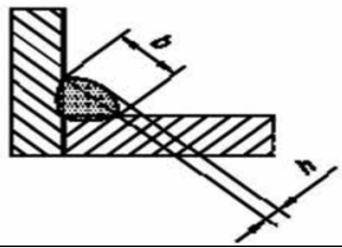
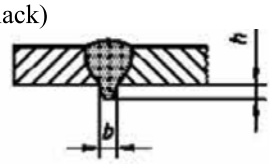
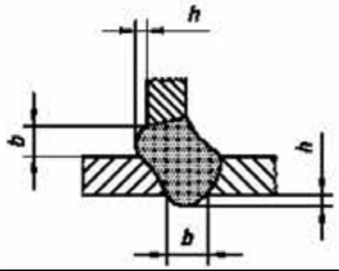
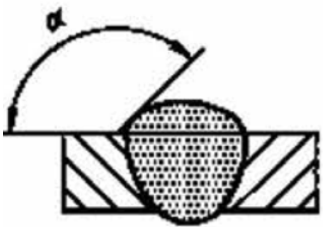
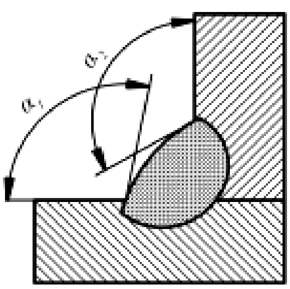
[7] Control level is not established.

3.4.2 Assessment of the welded joints quality by the visual testing and measurement results.

3.4.2.1 If otherwise is not agreed with the Register, assessment of the welded joints quality on the visual testing results shall be carried out in accordance with ДСТУ ISO 5817 or the applicable ISO standard for external imperfections (refer to Table 3.4.2.1) for quality levels specified as per **3.4.1.2** or **3.4.1.3**.

Table 3.4.2.1

No	Imperfection designation Reference to	ДСТУ EN ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ДСТУ ISO 5817			Remarks
				B	C	D	
1	2	3	4	5	6	7	8
1	Crack	100	-	Not permitted			
2	Crater crack	104	-	Not permitted			
3	Surface pore 	2017	d - maximum dimention:				Clusters and lines o n the weld surface are not permitted
			butt welds:	Not permitted	$d \le 0{,}2t$, but max. 2,0 mm	$d \le 0{,}3t$, but max. 2,0 mm	
			fillet welds	Not permitted	$d \le 0{,}2a$, but max. 2,0 mm	$d \le 0{,}2f$, but max. 2,0 mm	
4	End crater pipe 	2025	h- crater height (cross sectional dimension o f under cut)	Not permitted	$h \le 0{,}1t$, but max. 1,0 mm	$h \le 0{,}2t$, but max. 2,0 mm	For levels C and D may not be permitted under painting conditions
5	Lack of fusion (surfaced)	401	-	Not permitted			
6	Incomplete root penetration (for single sided butt welds) 	4021	h - maximum height l - maximum length of a single imperfection	Not permitted	Not permitted	$h \le 0{,}2t$, але не більше 2,0мм $l \le 0{,}25$мм	Для рівня D може не допускатися за умовами фарбування
7	Intermittent undercut and Continuous undercut: butt weld[1] 	5012, 5011	h - maximum height	$h \le 0{,}05t$, but max. 0,5 mm	$h \le 0{,}1t$, but max. 0,5 mm	$h \le 0{,}2t$, but max. 1,0 mm	[1] Simultaneous undercut o n both edges of the weld side is not permitted
	fillet joint 		h - maximum height	$h \le 0{,}05t$, but max. 0,5 mm	$h \le 0{,}1t$, but max. 0,5 mm	$h \le 0{,}2t$, but max. 1,0 mm	
8	Strinkage grooves (undercuts on both sides of the weld)	5013	h - maximum height l - maximum length of a single imperfection	$h \le 0{,}05t$, but max. 0,5 mm $l \le 25$mm	$h \le 0{,}1t$, but max. 0,5 mm $l \le 25$mm	$h \le 0{,}2t$, but max. 2,0 mm $l \le 25$mm	

							
9	Excess weld metal 	502	*h* - maximum height reinforcement *b* - breadth of reinforcement	*h* ≤ 1mm + 0,1*b* but max. 5 mm	*h* ≤ 1 mm + 0,15*b* but max. 7 mm	*h* ≤ 1mm + 0,25*b* but max.10 mm	
10	Excessive convexity 	503	*h* - maximum convexity *b* - breadth of reinforcement	*h* ≤ 1mm + 0,1*b* but max. 3 mm	*h* ≤ 1mm + 0,15*b* but max. 4 mm	*h* ≤ 1mm + 0,25*b* but max. 5 mm	
11	Excessive penetration (weld root slack)  	504	*h* - maximum penetration height *b* - breadth of penetration	*h* ≤ 1 mm + 0,2*b* but max. 3 mm	*h* ≤ 1 mm + 0,6*b* but max. 4 mm	*h* ≤ 1 mm + 1,0*b* but max. 5 mm	
12	Incorrect weld toe: butt welds  fillet welds α1 ≥ α2, α2 ≥ α 	505	*α* – angle between base metal surface and flat surface tangent t o convexity	*α ≥ 150º* *α ≥ 110º*	*α ≥ 100º* *α ≥ 110º*	*α ≥ 90º* *α ≥ 90º*	For smooth transition for quality levels B and C special handling of the weld may be required
13	Overlap	506	*H* - overlap dimension	Not permitted	Not permitted	*h ≤ 0,2b*	

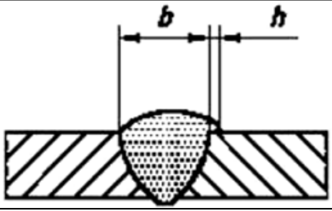
	 b h						

Table 3.4.2.1 continue

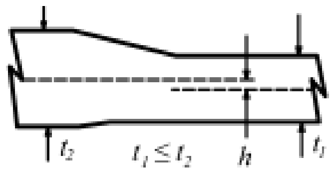
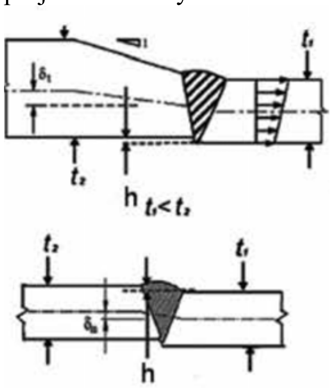
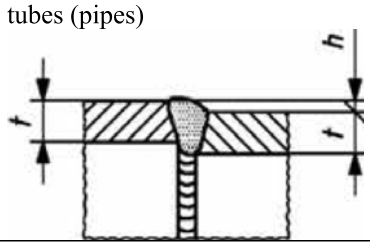
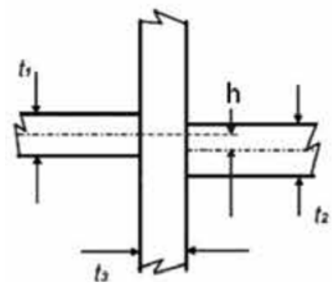
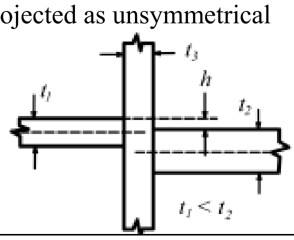
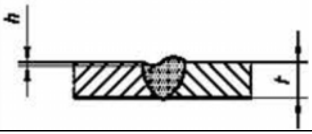
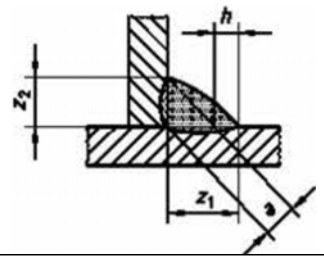
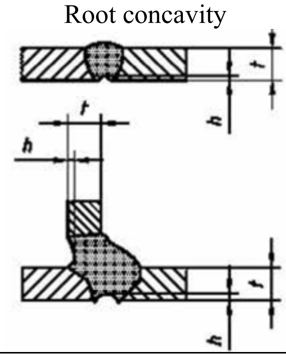
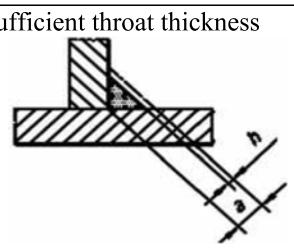
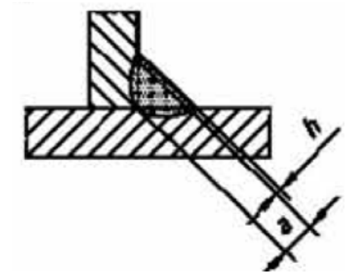
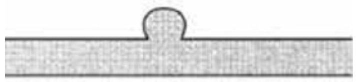
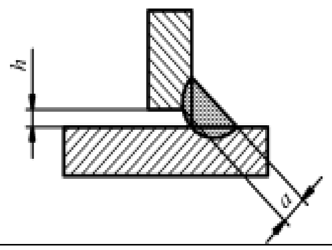
1	2	3	4	5	6	7	8
14	Linear misalignment between plates and caps of pipes: projected as symmetrical;  projected as unsymmetrical 	5071	h - height of linear misalignment defined a s misalignment of axes along the thickness plates	$h \le 0{,}1t_1$, but max. 3 mm	$h \le 0{,}15t_1$, but max. 4 mm	$h \le 0{,}25t_1$, but max. 5 mm	
			defined as deviation of external plate line	$h \le 0{,}1t_1$, but max. 3 mm	$h \le 0{,}15t_1$, but max. 4 mm	$h \le 0{,}25t_1$, but max. 5 mm	
15	Linear misalignment between tubes (pipes) 	5072	h - height of linear misalignment defined as the deviation of the welded pipes external diameter $t = \min\{t_1 \text{ i } t_2\}$	$h \le 0{,}5t$, but max. 2 mm	$h \le 0{,}5t$, but max. 3 mm	$h \le 0{,}5t$, but max. 4 mm	
16	Linear misalignment of cruciform joints: projected as symmetrical  projected as unsymmetrical 		h - height of linear misalignment: defined a s deviation o f axes along the thickness plates $t = \min\{t_1, t_2, t_3\}$	$h \le 0{,}15t$	$h \le 0{,}3t$	$h \le 0{,}5t$	
			defined a s deviation o f common external line of plates $t = \min\{t_1, t_2, t_3\}$	$h \le 0{,}15t$	$h \le 0{,}3t$	$h \le 0{,}5t$	

Table 3.4.2.1 continue

1	2	3	4	5	6	7	8
17	Sagging Incompletely filled groove 	509 511	*h* - height of sagging o r incompleteness of groove *l* – length of imperfection	$h \le 0{,}05t$, but max. 0,5 mm $l \le 25$mm	$h \le 0{,}1t$, but max. 1 mm $l \le 25$mm	$h \le 0{,}25t$, but max. 2,0 mm $l \le 25$mm	
18	Burn-through (leakage of welding bath with formation of through hole in the weld)	510		Not permitted	Not permitted	Not permitted	
19	Excessive asymmetry of fillet weld 	512	$h = z_1 - z_2$ - height o f asymmetry (different leg lengths)	$h \le 1{,}5$ mm + $0{,}15a$,	$h \le 1{,}5$ mm + $0{,}15a$,	$h \le 1{,}5$ mm + $0{,}15a$,	
20	Irregular surface: pimpling and scaling;	514	*h* - height of pimpling and scaling	$h \le 1{,}5$mm	$h \le 2$ mm	$h \le 2$ mm	Height o f drops between beads, height of pimpling and scaling shall b e measured among tops of pimpling and scaling
	drops between beads		*h* - height of drops between beads	$h \le 1{,}5$mm	$h \le 2$ mm	$h \le 2$ mm	
21	Root concavity 	515	*h* - height of root concavity *l* - length of imperfection	$h \le 0{,}05t$, but max. 0,5 mm $l \le 25$mm	$h \le 0{,}1t$, but max. 1 mm $l \le 25$mm	$h \le 0{,}2t$, but max. 2 mm $l \le 25$mm	
22	Root porosity: spongy formation in the root of the weld, which has arisen as a result of gas evolution during crystallization (for example, with insufficient gas protection of the root of the weld)	516		Not permitted	Not permitted	Permitted but only local	May not be permitted for level D under conditions of painting
23	Poor restart: local surface roughness at the place of resumption of welding	517		Not permitted	Not permitted	Permitted	May not be permitted for level D under conditions of painting
24	Insufficient throat thickness 	5213	*h* - height if insufficience (reduction from nominal dimension) of fillet weld thickness a «*a*» *l*- length of imperfection	Not permitted	$h \le 0{,}3$ mm + $0{,}1a$ but max. 1 mm $l \le 25$mm	$h \le 0{,}3$ mm + $0{,}1a$ but max. 1 mm $l \le 25$mm	

End of Table 3.4.2.1

1	2	3	4	5	6	7	8
25	Excessive throat thickness 	5214	h - height of excessive throat of fillet weld thickness «a»	$h \leq 1$ mm + 0,15a but max. 3 mm	$h \leq 1$ mm + 0,2a but max 4 mm	Unlimited	
26	Stray arc: local breakage of the base metal surface close to weld due to arc burning outside grooving	601		Not permitted	Not permitted	Permitted, if the properties of the base metal are not affected	Refer to Table 9.13, Part A, IACS Standard No. 47
27	Spatter 	602		Not permitted	To be removed from the surface subject to coating requirements.		Refer to para. **4.2.4.2**, Part A, IACS Standard No. 47
28	Incorrect root gap for fillet welds 	617	h - – height of root gap of single sided weld a - – thickness of fillet weld	$h \leq 0,5$mm + 0,1a but max 2 mm	$h \leq 0,5$mm + 0,2a but max 3 mm	$h \leq 1$ mm + 0,3a but max 4 mm	On agreement with the Register gaps exceeding the appropriate limit may be compensated for b y a corresponding increase in the throat.

3.4.2.2 All imperfections detected on the visual testing and measurement results shall be removed and the location of corrections shall be tested again in compliance with **3.1.5**.

3.4.2.3 On the visual testing and measurement results the welded joints shall be considered fit/accepted if inadmissible imperfections are not detected for an acceptable level listed in Table 3.4.2.1.

3.4.3 Assessment of the welded joints quality by the magnetic particle testing results.

3.4.3.1 If otherwise is not agreed with the Register, assessment of the welded joints quality on the magnetic particle testing results shall be carried out in accordance with ДСТУ EN ISO 23278 or the applicable ISO or EN standards refer to Table 3.4.3.1) for the quality levels specified by the requirements **3.4.1.2** or **3.4.1.3**.

Table 3.4.3.1

Type of indicator trace	Assessment level (quality grade) in compliance with ДСТУ EN ISO 23278[1] or the applicable ISO or EN standards		
	1	2	3
Linear[2] l - indicator bead length	$l \leq 1{,}5$mm	$l \leq 3$mm	$l \leq 6$mm
d - size of a major axis of the indicator bead	$d \leq 2$mm	$d \leq 3$mm	$d \leq 4$mm

[1] Acceptance levels 2 and 3 may include an index «x» designating that all the linear indicator beads shall be assessed as per level 1.
[2] A linear indicator bead is an indicator bead with its length exceeding the width of more than three times.
[3] Non-linear indicator bead is an indicator bead with its length equal to or less than three widths.

3.4.3.2 To reduce the dimensions or remove the imperfections that caused inadmissible indicator beads (indications), local grinding or cleaning can be used if permitted as per the production specifications for a particular product. Location of corrections shall be subject to re-inspection and assessment in accordance with the specification used for the initial testing as per **3.1.5**.

3.4.3.3 On the magnetic particle testing results the welded joints shall be considered fit/accepted if inadmissible imperfections are not detected for an acceptable level listed in Table 3.4.3.1.

3.4.4 Assessment of the welded joints quality by the dye penetrant testing results.

3.4.4.1 1 If otherwise is not agreed with the Register, assessment of the welded joints quality on the dye penetrant testing results shall be carried out in accordance with ДСТУ EN ISO 23277 or the applicable ISO or EN standards (refer to Table 3.4.4.1) for the quality levels specified by the requirements **3.4.1.2** or **3.4.1.3**.

Table 3.4.4.1

Type of indicator trace	Assessment level (quality grade) in compliance with ДСТУ EN ISO 23277[1] or the applicable ISO or EN standards		
	1	2	3
Linear[2] *l* - indicator bead length	$l \leq 2$mm	$l \leq 4$mm	$l \leq 8$mm
Non-linear [3] *d* - size of a major axis of the indicator bead	$d \leq 4$mm	$d \leq 6$mm	$d \leq 8$mm

[1] Acceptance levels 2 and 3 may include an index «x» designating that all the linear indicator beads shall be assessed as per level 1.
[2] A linear indicator bead is an indicator bead with its length exceeding the width of more than three times.
[3] Non-linear indicator bead is an indicator bead with its length equal to or less than three widths.

3.4.4.2 To reduce the dimensions or remove the imperfections that caused inadmissible indicator beads (indications), local grinding or cleaning can be used if permitted as per the production specifications for a particular product. Location of corrections shall be subject to re-inspection and assessment in accordance with the specification used for the initial testing as per **3.1.5**.

3.4.4.3 On the dye penetrant testing results the welded joints shall be considered fit/accepted if inadmissible imperfections are not detected for an acceptable level listed in Table 3.4.4.1.

3.4.5 Assessment of the welded joints quality by the radiographic testing results.

3.4.5.1 At the radiographic testing assessment of the welded joints quality shall be carried out with interpretation of the images on radiographs for the following types of internal imperfections:

pores;
slag inclusions;
metal tungsten inclusions;
metal coper inclusions;
poor fusion;
lack of fusion;
cracks.

Surfaced imperfections in welds shall be assessed in compliance with **3.4.2.1**.

3.4.5.2 For the dimensions of the welded joints imperfections under radiographic control shall be taken dimensions of their images on radiographs in accordance with the following requirements.

The following are accepted for the dimensions of the pores, slag or tungsten inclusions:

for spherical pores and inclusions their diameter *d*, as measured by the longest axis;

for elongated pores and inclusions their length *l* and width *h*.

Note. Inclusion is extended (linear) if its length is more than three times the maximum width or diameter.

For the dimensions of lack of fusion, incomplete penetration and cracks their length *l* is accepted.

If the distance between similar imperfections in-line is less than the size of the smallest imperfections, such imperfections shall be one extended imperfections. Dimensions of such an imperfection shall be defined as the distance measured by the outermost edges of the group imperfections.

If the distance between arranged parallel uniform extended imperfections is less than 3 times the width of the smallest imperfection, these imperfections shall be considered as an extended imperfection. Dimensions of such an imperfection shall be defined as the distance measured by the outermost edges of the group imperfections.

If more than one pore is located within the circle of a diameter equal to 3 times a pore diameter, such imperfections are considered group porosity or pore accumulation (cluster). For the cluster size the distance measured at the outermost edges of each other imperfections in the cluster shall be taken.

If the distance between two and more in-line uniform imperfections of one but not more than three extensions (diameter or length) of the smallest imperfections, those imperfections are called a line. For the inclusion line size the length measured at the outermost edges of each other imperfections in the line shall be taken.

3.4.5.3 If otherwise is not agreed with the Register, assessment of the welded joints quality on the radiographic testing results shall be carried out in accordance with ДСТУ EN ISO 10675-1 or the applicable ISO or EN standards (refer to Table 3.4.5.3) for the quality levels specified by the requirements **3.4.1.2** or **3.4.1.3**.

Table 3.4.5.3

No	Imperfection designation	Reference to ДСТУ EN ISO 6520-1	Specifications of imperfections	Limits for imperfection for quality levels		
				1	2[1]	3[1]
1	2	3	4	5	6	7
1	Crack	100	-	Not permitted	Not permitted	Not permitted
2a	Gas pore and Uniformly distributed porosity Single layer weld	2011 2012	*A* - the sum of the different pore areas related to the evaluation area *Wp* x *L* *d* - maximum pore diameter	$A \leq 1\%$ $d \leq 0{,}2s$, but max. 3 mm L = 100 mm	$A \leq 1{,}5\%$ $d \leq 0{,}3s$, but max. 4 mm $L = 100$ mm	$A \leq 2{,}5\%$ $d \leq 0{,}4s$, but max.5 mm $L = 100$ mm
2b	Gas pore Uniformly distributed porosity Multi layer weld	2011 2012	*A* - the sum of the different pore areas related to the evaluation area *Wp* x *L* *d* - maximum pore diameter	$A \leq 2\%$ $d \leq 0{,}2s$, but max. 3 mm L = 100 mm	$A \leq 3\%$ $d \leq 0{,}3s$, but max. 4 mm $L = 100$ mm	$A \leq 5\%$ $d \leq 0{,}4s$, but max.5 mm $L = 100$ mm
3	Clustered (localized) porosity	2013	*A* - the sum of the different pore areas related to the evaluation area *Wp* x *L* *d* - maximum pore diameter	$A \leq 4\%$ $d \leq 0{,}2s$, but max. 2 mm $L = 100$ mm	$A \leq 8\%$ $d \leq 0{,}3s$, but max. 4 mm $L = 100$ mm	$A \leq 16\%$ $d \leq 0{,}4s$, but max. 4 mm $L = 100$ mm
4a	Linear porosity (Lines) Single layer weld	2014	*A* - the sum of the different pore areas related to the evaluation area *Wp* x *L* *d* - maximum pore diameter	$A \leq 2\%$ $d \leq 0{,}2s$, but max. 2 mm $L = 100$ mm	$A \leq 4\%$ $d \leq 0{,}3s$, but max. 3 mm L = 100 mm	$A \leq 8\%$ $d \leq 0{,}4s$, but max. 4 mm $L = 100$ mm
4b	Linear porosity (Lines) Multi layer weld	2014	*A* - сума площ проекцій пор віднесена до площі знімка *Wp* x *L* *d* - максимальний діаметр пор	$A \leq 4\%$ $d \leq 0{,}2s$, but max. 2 mm $L = 100$ mm	$A \leq 8\%$ $d \leq 0{,}3s$, but max. 3 mm $L = 100$ mm	$A \leq 16\%$ $d \leq 0{,}4s$, but max. 4 mm $L = 100$ mm
5	Wormholes (pipes) and Elongated cavity	2016 2015	*h*- width of imperfection projection Σl- maximum total length of weld imperfection projection *L*	$h < 0{,}2s$, but max. 2 mm $\Sigma l \leq s$, but max. 25 mm $L = 100$ mm	$h<0{,}3s$, but max. 3 mm $\Sigma l \leq s$, but max. 25 mm $L = 100$ mm	$h<0{,}4s$, but max. 4 mm $\Sigma l \leq s$, but max. 75 mm $L = 100$ mm
6	Shrinkage cavity (except for crater pipe – 2024)	202	*h* - width of imperfection projection *l* - length of imperfection projection	Not permitted	Not permitted	$h < 0{,}4s$, but max. 4 mm $l \leq 25$mm
7	Crater pipe	2024	*h* - width of imperfection projection *l* - length of imperfection projection	Not permitted	Not permitted	$h < 0{,}2t$, but max. 2 mm $l \leq 0{,}2t$, but max. 2 mm
8	Slag inclusions, Flux inclusions Oxide inclusions	301 302 303	*h* - width of imperfection projection Σl- maximum total length of weld imperfection projection *L*	$h < 0{,}2s$, but max. 2 mm $\Sigma l \leq s$, but max. 25 mm $L = 100$ mm	$h < 0{,}3s$, but max. 3 mm $\Sigma l \leq s$, but max. 25 mm $L = 100$ mm	$h <0{,}4s$, but max. 4 mm $\Sigma l \leq s$, but max. 75 mm L= 100мм
9	Metallic inclusions other than copper	304	*l*- length of imperfection projection	$h < 0{,}2s$, but max. 2 mm	$h < 0{,}3s$, but max. 3 mm	$h <0{,}4s$, but max. 4 mm
10	Copper inclusiond	3042		Not permitted	Not permitted	Not permitted
11[2]	Lack of fusion	401	Σl - maximum total length of weld imperfection projection *L*	Not permitted	Not permitted	Permitted but only intermittent and not surfaced

						$\Sigma l \leq 25$mm $L = 100$mm
12[2]	Lack of penetration	402	Σl - maximum total length of weld imperfection projection L	Not permitted	Not permitted	$\Sigma l \leq 25$mm $L = 100$mm

Symbols:
L - any (with imperfection maximum density) 100 mm weld length;
s - nominal thickness of the butt weld;
t - material thickness;
Wp - weld width.
Note. The applicable ISO and EN standards maybe applied along with the specified DSTU standards.
[1] Quality levels 2 and 3 cab have index "x" which designates all imperfections above 25 mm and are not permitted.
[2] If the weld length is under 100 mm the maximum imperfection length shall not be above 25 % of that length.

3.4.5.4 All detected imperfections inadmissible for the specified accepted level on the radiographic testing and measurement results shall be removed and the location of corrections shall be tested again in accordance with **3.1.5**.

3.4.6 Assessment of the welded joints quality by the ultrasonic testing results.

3.4.6.1 1 If otherwise is not agreed with the Register, assessment of the ultrasonic testing results shall be carried out in accordance with the accepted levels based on the echo-signal length and amplitude as per ДСТУ EN ISO 11666 or the applicable ISO and EN standards (refer to Table 3 3.4.6.1) and the following requirements for their application and interpretation of the testing results as regards instructions of **5.1** of the above mentioned standard.

3.4.6.2 All imperfections, echosignal level of which exceeding the reference level of sensitivity, shall be assessed in accordance with the definition of the characteristics of ДСТУ EN ISO 23279 or the applicable ISO and EN standards, Stage 3 in order to identify the planar (two-dimensional) imperfections.

3.4.6.3 All the specified as per **3.4.6.2** planar (two-dimensional) imperfections are considered inadmissible and subject to be corrected.

3.4.6.4 All detected imperfections inadmissible for the specified accepted level on the ultrasonic testing results shall be removed and the location of corrections shall be tested again in accordance with **3.1.5**.

Table 3.4.6.1

Method for setting the reference level according to ДСТУ EN ISO 17640[1]	Evaluation level of sensitivity for Acceptance level[2]		Acceptance level 2 (AL 2) for thicknesses [2, 3, 4]		Acceptance level 3 (AL 3) for thicknesses [2, 3, 4]	
	2	3	8mm $\leq t$ <15mm	15mm $\leq t$ <100mm	8mm $\leq t$ < 15mm	15mm $\leq t$ < 100mm
1	2	3	4	5	6	7
1 (side-drilled holes)	H_0 -14 dB	H_0 -10 dB	For $l \leq t$; H_0 - 4 dB For $l > t$; H_0-10 dB	For $l \leq 0,5t$; H_0 For $0,5t < l \leq t$; H_0- 6 dB For $l > t$; H_0 - 10 dB	For $l \leq t$; H_0 For $l > t$; H_0 - 6 dB	For $l \leq 0,5t$; H_0 + 6 dB For $0,5t < l \leq t$; H_0 -2 dB For $l > t$; H_0 -6 dB
2 (flat-bottom holes (disk-shaped reflectors))	H_0 -8 dB	H_0 -4 dB	For $l \leq t$; H_0+2 dB For $l > t$; H_0-10 dB	For $l \leq 0,5t$; H_0 + 6дБ For $0,5t < l \leq t$; H_0 For $l > t$; H_0 - 4 dB	For $l \leq t$; H_0 +6 dB For $l > t$; H_0	For $l \leq 0,5t$; H_0 +10 dB For $0,5t < l \leq t$; H_0 +4 dB For $l > t$; H_0
3 (rectangular notch)	H_0 -14 dB	H_0 -10 dB	For $l \leq t$; H_0 -4 dB For $l > t$; H_0-10 dB	–	For $l \leq t$; H_0 For $l > t$; H_0 - 6дБ	–
4 (tandem technique)	H_0 -22 dB	H_0 -18 dB	–	For $l \leq 0,5t$; H_0 - 8 dB For $0,5t < l \leq t$; H_0-14 dB For $l > t$; H_0 - 14 dB	–	For $l \leq 0,5t$; H_0 - 14 dB For $0,5t < l \leq t$; H_0 - 0 dB For $l > t$; H_0 - 14 dB

[1] Refer to **3.2.5.14**.
[2] H_0 - reference level according to ДСТУ EN ISO 17640 (refer to **3.2.5.13**).
[3] l - length of imperfection.
[4] t - thickness of base metal.

3.5 ASSESSMENT OF WELDED JOINT QUALITY IN ALUMINIUM ALLOY HULL STRUCTURES

3.5.1 General.

3.5.1.1 The assessment of welded joint quality in aluminium alloy hull structures shall be carried out in compliance with quality levels of the relevant requirements of ДСТУ EN ISO 10042 or the applicable ISO and EN standards or other international and national standards recognized by the Register.

3.5.1.2 Requirements for the quality levels that meet the requirements of ДСТУ EN ISO or the applicable ISO and EN standards, 2 for hull structures of ships shall be agreed with the Register individually depending on the type of a ship and its size. In any case, an acceptable level of quality shall be at least "C" in accordance with ДСТУ EN ISO or the applicable ISO and EN standards except for the size requirements for weld reinforcement during an external examination and measurements, which can be lowered to level "D" as agreed with the Register.

3.5.1.3 For specific non-destructive testing procedure acceptable levels of imperfection acceptance in accordance with the specified quality levels as per ДСТУ EN ISO 10042 or the applicable ISO and EN standards, as well as the requirements for the class and procedure of control are established by the requirements of the relevant international standards and shall be assigned in accordance with Table 3.5.1.3.

3.5.1.4 Assessment of the welded joints quality within each level of assessment of imperfections shall be performed as per an alternative system of "fit-unfit" ("acceptance - non-acceptance") applying assessment criteria, according to **3.5.2, 3.5.3, 3.5.4**.

Table 3.5.1.3

Quality level in compliance with ДСТУ EN ISO 10042	Requirements for radiographic testing		Requirements for penetrant methods	
	Methods and class as per ДСТУ EN ISO 17636	Assessment level (quality grade) in compliance with ДСТУ EN ISO 10675-2	Methods and class as per ДСТУ EN ISO 3452	Assessment level (quality grade) in compliance with ДСТУ EN ISO 23277
B	B	1	Test Class (level) is not specified	2×
C	B[1]	2		2×
D	A	3		3×

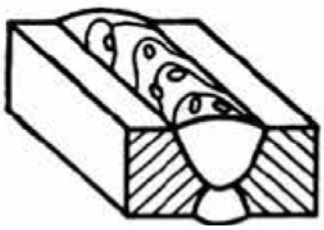
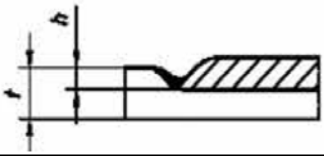
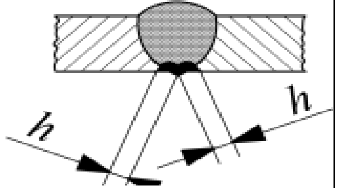
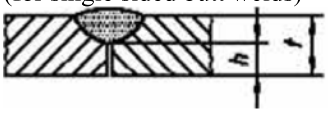
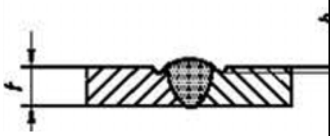
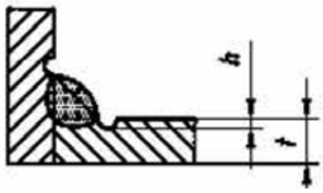
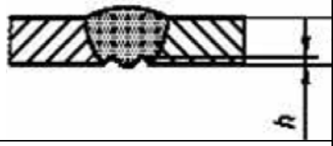
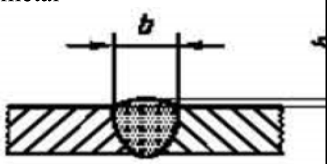
[1] For circumferential piping welded joints minimum quantity of exposures (radiographs) can comply with the requirements for class A ДСТУ EN ISO 17636.
Note. The applicable ISO and EN standards maybe applied along with the specified DSTU standards.

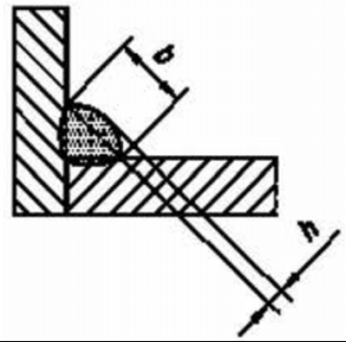
3.5.2 Assessment of the welded joints quality by the visual testing and measurement results.

3.5.2.1 If otherwise is not agreed with the Register, assessment of the welded joints quality on the visual testing results shall be carried out in accordance with ДСТУ EN ISO 10042 or the applicable ISO and EN standards (refer to Table 3.5.2.1) for the quality levels agreed with the Register.

Table 3.5.2.1

No.	Imperfection designation	Reference toДСТУ EN ISO 6520	Specifications of imperfections and the weld dimensions	Limits for imperfections for quality levels ДСТУ ISO 5817			Remarks
				B	C	D	
1	2	3	4	5	6	7	8
1	Crack	100	-	Not permitted			
2	Crater crack	104	l – length h – height	Not permitted		$l \le 0{,}4t$ or $l \le 0{,}4a$ $h \le 0{,}4t$ or $h \le 0{,}4a$	
3	Surface pore	2017	d - maximum dimension for weld profile concavity: $0{,}5\text{mm} \le t \le 3\text{mm}$	$d \le 0{,}1t$ or $d \le 0{,}1a$,	$d \le 0{,}2t$ or $d \le 0{,}2a$,	$d \le 0{,}3t$ or $d \le 0{,}3a$	Clusters and lines on the weld surface are not permitted

			t > 3mm	$d \le 0{,}2t$ or $d \le 0{,}2a$, but max. 1 mm	$d \le 0{,}2t$ or $d \le 0{,}2a$, but max. 1.5 mm	$d \le 0{,}4t$ or $d \le 0{,}4a$, but max. 3 mm	
4	End crater pipe 	2025	h - crater height (cross sectional dimension of undercut)	Not permitted	$h \le 0{,}2t$, but max. 1.5 mm	$h \le 0{,}4t$, but max. 3 mm	For levels C and D may not be permitted under painting conditions
5	Lack of fusion (surfaced) 	401	h - height l - length of a single imperfection	Not permitted	Not permitted	$h \le 0{,}1t$ або $h \le 0{,}1a$, but max. 3 mm $l \le 25$mm	
6	Incomplete root penetration (for single sided butt welds) 	4021	h – maximum height l - length of a single imperfection	Not permitted	Not permitted	$h \le 0{,}2t$, but max. 2,0 mm $l \le 25$mm Single non systematical imperfections may be permitted	For level D may not be permitted under painting conditions
7	Undercut: continuous: 	5011	h – maximum height	Not permitted	Not permitted	$h \le 0{,}2t$, but max. 1 mm	
	intermittent 	5012	h – maximum height l - length of a single imperfection	$h \le 0{,}01t$, but max. 0.5 mm $l \le 25$mm	$h \le 0{,}1t$, but max. 1 mm $l \le 25$mm	$h \le 0{,}2t$, but max. 1 mm $l \le 25$mm	
8	Strinkage grooves (undercuts on both sides of the weld) 	5013	h – maximum height l - length of a single imperfection	$h \le 0{,}05t$, but max. 0.5 mm $l \le 25$mm	$h \le 0{,}1t$, but max. 1 mm $l \le 25$mm	$h \le 0{,}2t$, but max. 2 mm $l \le 25$mm	
9	Excess weld metal 	502	h - maximum reinforcement height b - breadth of reinforcement	$h \le$ 1,5mm + 0,1b, but max. 6 mm	$h \le$ 1 mm + 0,15b, but max. 8 mm	$h \le$ 1,5mm + 0,2b, but max. 10 mm	

10	Excessive convexity 	503	h - maximum convexity b - breadth of fillet weld	$h \leq$ 1,5mm + 0,1b, but max. 3 mm	$h \leq$ 1,5mm + 0,15b, but max. 4 mm	$h \leq$ 1,5mm + 0,3b, but max. 5 mm	

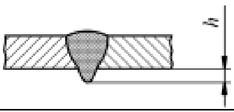
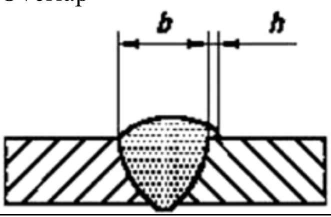
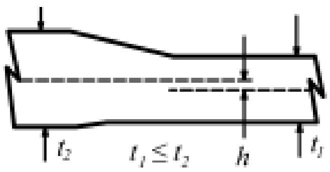
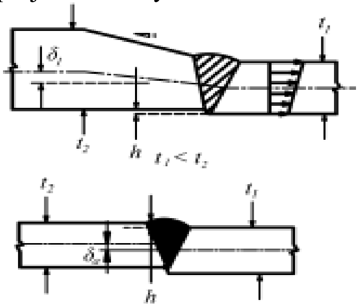
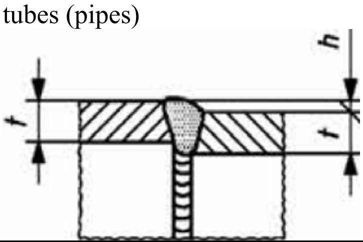
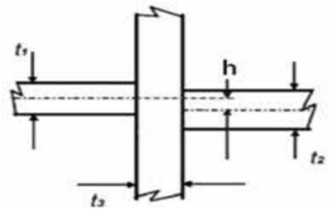
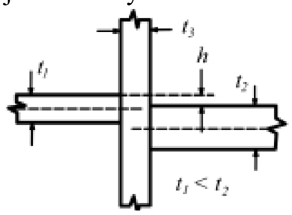
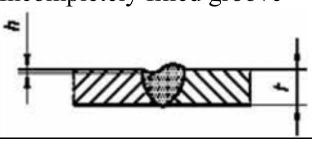
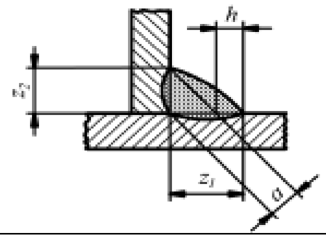
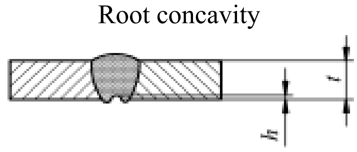
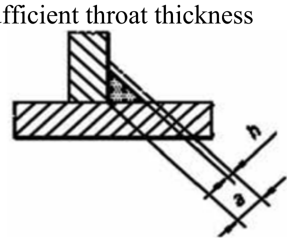
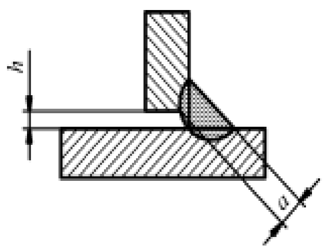
1	2	3	4	5	6	7	8
11	Excessive penetration 	504	h - maximum penetration height b - breadth of penetration	$h \leq$ 3mm	$h \leq$ 4mm	$h \leq$ 5mm	
12	Overlap 	506	h - overlap height l - length of a single imperfection	Not permitted	Not permitted	$h \leq 0{,}2t$, $l \leq$ 25mm	
13	Linear misalignment between plates and caps of pipes: projected as symmetrical 	5071	h - dimension of linear misalignment: defined a s misalignment of axes along the thickness plates	$h \leq 0{,}2t$, but max. 2 mm	$h \leq 0{,}3t$, but max. 4 mm	$h \leq 0{,}4t$, but max. 8 mm	
	projected as asymmetrical 		defined as deviation of external plate line	$h \leq 0{,}2t_1$, but max. 2 mm	$h \leq 0{,}3t_1$, but max. 4 mm	$h \leq 0{,}4t_1$, but max. 8 mm	
14	Linear misalignment between tubes (pipes) 	5072	h - height of linear misalignment defined as the deviation of the welded pipes external diameter $t = \min\{t_1 \text{ i } t_2\}$	$h \leq 0{,}2t$, but max. 4 mm	$h \leq 0{,}3t$, but max. 6 mm	$h \leq 0{,}4t$, but max. 10 mm	

Table 3.5.2.1continue

1	2	3	4	5	6	7	8
15	Linear misalignment of cruciform joints: projected as symmetrical 		h - – height of linear misalignment defined as deviation of axes along the thickness plates $t = \min\{t_1, t_2, t_3\}$	$h \le 0{,}2t$	$h \le 0{,}4t$	$h \le 0{,}5t$	
	projected as asymmetrical 		defined as deviation of common external line of plates $t = \min\{t_1, t_2, t_3\}$	$h \le 0{,}15t$	$h \le 0{,}3t$	$h \le 0{,}5t$	
16	Sagging Incompletely filled groove 	509 511	h - height of sagging or incompleteness of groove l – length of imperfection	$h \le 0{,}05t_1$, but max. 0.5 mm $l \le 25$mm	$h \le 0{,}1t_1$, but max. 1 mm $l \le 25$mm	$h \le 0{,}2t_1$, but max. 2 mm $l \le 25$mm	
17	Excessive asymmetry of fillet weld 	512	$h = z_1 - z_2$ - height of asymmetry (different leg lengths)	$h \le$ 1,5mm + 0,2a,	$h \le$ 2mm + 0,25a,	$h \le$ 3mm + 0,3a,	
18	Root concavity 	515	h – height of root concavity l- – length of imperfection	$h \le 0{,}05t$, but max. 0.5 mm $l \le 25$mm	$h \le 0{,}1t$, but max. 1 mm $l \le 25$mm	$h \le 0{,}2t$, but max. 2 mm $l \le 25$mm	
19	Insufficient throat thickness 	5213	h - – height if insufficience (reduction from nominal dimension) of fillet weld thickness «a» l- length of imperfection	$h \le 0{,}1a$, but max. 1 mm $l \le 25$mm	$h \le 0{,}2a$, but max. 1.5 mm $l \le 25$mm	$h \le 0{,}3a$, but max. 1 mm $l \le 25$mm	
20	Incorrect root gap for fillet weld 	617	h - height of root gap of single sided weld a - thickness of fillet weld	$h \le$ 0,5mm + 0,1a, but max. 3 mm	$h \le$ 0,5mm + 0,2a, but max. 3 mm	$h \le$ 1mm + 0,3a, but max. 4 mm	On agreement with the Register gaps exceeding the appropriate limit may be compensated for by a corresponding increase in the throa

3.5.2.2 All imperfections detected on the visual testing and measurement results shall be removed and the location of corrections shall be tested again in compliance with **3.1.5**.

3.5.2.3 On the visual testing and measurement results the welded joints shall be considered fit/accepted if inadmissible imperfections are not detected for an acceptable level listed in Table 3.5.2.1.

3.5.3 Assessment of the welded joints quality by the dye penetrant testing results.

3.5.3.1 If otherwise is not agreed with the Register, assessment of the welded joints quality on the dye penetrant testing results shall be carried out in accordance with ДСТУ EN ISO 23277 or the applicable ISO or EN standards (refer to Table 3.5.3.1) for the quality levels agreed with the Register.

Table 3.5.3.1

- type of indicator	Assessment level (quality grade) in compliance with ДСТУ EN ISO 23277[1]		
	1	2	3
Linear[2] *l* - _ indicator bead length	$l \leq$ 2mm	$l \leq$ 4mm	$l \leq$ 8mm
Non-linear[3] *d* - size of a major axis of the indicator bead	$d \leq$ 4mm	$d \leq$ 6mm	$d \leq$ 8mm

[1] Acceptance levels 2 and 3 may include an index «x» designating that all the linear indicator beads shall be assessed as per level 1.
[2] A linear indicator bead is an indicator bead with its length exceeding the width of more than three times.
[3] Non-linear indicator bead is an indicator bead with its length equal to or less than three widths.

3.5.3.2 To reduce the dimensions or remove the imperfections that caused inadmissible indicator beads (indications), local grinding or cleaning can be used if permitted as per the production specifications for a particular product. Location of corrections shall be subject to re-inspection and assessment in accordance with the specification used for the initial testing as per **3.1.5**.

3.5.3.3 On the dye penetrant testing results the welded joints shall be considered fit/accepted if inadmissible imperfections are not detected for an acceptable level listed in Table 3.5.3.1.

3.5.4 Assessment of the welded joints quality by the radiographic testing results.

3.5.4.1 1 At the radiographic testing assessment of the welded joints quality shall be carried out with the interpretation of the images on radiographs for the following types of internal imperfections:

pores;
solid (oxide) inclusions;
metal tungsten inclusions;
poor fusion;
lack of fusion;
cracks.

Surfaced imperfections in welds shall be assessed in compliance with **3.5.2.1**.

3.5.4.2 For the dimensions of the welded joints imperfections under radiographic control shall be taken dimensions of their images on radiographs in accordance with the following requirements.

The following are accepted for the dimensions of the pores, slag or tungsten inclusions:

for spherical pores and inclusions their diameter *d*, as measured by the longest axis;

for extended inclusions their length *l* and the width *h*.

For the dimensions of lack of fusion, incomplete penetration and cracks their length l is accepted.

If the distance between similar imperfections inline is less than the size of the smallest imperfection, such imperfections shall be one extended imperfection. Dimensions of such an imperfection shall be defined as the distance measured by the outermost edges of the group imperfections.

If the distance between arranged parallel uniform extended imperfections is less than 3 times the width of the smallest imperfection, these imperfections shall be considered as an extended imperfection. Dimensions of such an imperfection shall be defined as the distance measured by the outermost edges of the group imperfections.

If more than one pore is located within the circle of a diameter equal to 3 times a pore diameter, such imperfections are considered group porosity or pore accumulation (cluster). For the cluster size the distance measured at the outermost edges of each other imperfections in the cluster shall be taken.

If the distance between two and more in-line uniform imperfections of one but not more than three extensions (diameter or length) of the smallest imperfections, those imperfections are called a line. For the inclusion line size the length measured at the outermost edges of each other imperfections in the line shall be taken.

3.5.4.3 If otherwise is not agreed with the Register, assessment of the welded joints quality on the radiographic testing results shall be carried out in accordance with ДСТУ EN ISO 10675-2 or the applicable ISO or EN standards (refer to Table 3.5.4.3) for the quality levels agreed with the Register.

3.5.4.4 All detected imperfections inadmissible for the specified accepted level on the radiographic testing and measurement results shall be removed and the location of corrections shall be tested again in compliance with **3.1.5**.

Table 3.5.4.3

No.	Imperfection designation	Reference to ДСТУ EN ISO 6520-1	Specifications of imperfections	Limits for imperfection for quality levels		
				1	2[1]	3[1]
1	2	3	4	5	6	7
1	Crack	100	-	Not permitted	Not permitted	Not permitted
2a	Gas pore	2011	d - maximum pore diameter	$d \le 0{,}2s$, but max. 4mm	$d \le 0{,}3s$, but max. 5mm	$d \le 0{,}4s$, but max. 6mm
2b	Uniformly distributed porosity Material thickness 0,5mm $\le s \le$3mm	2012	A - the sum of the different pore areas related to the evaluation area: Wp x L	$A \le 1\%$ L = 100mm	$A \le 2\%$ L = 100mm	$A \le 6\%$ L = 100mm
2c	Uniformly distributed porosity Material thickness 3mm $\le s \le$12mm	2012	A – the sum of the different pore areas related to the evaluation area: Wp x L	$A \le 2\%$ L = 100mm	$A \le 4$ % L = 100mm	$A \le 10\%$ L = 100mm
2d	Uniformly distributed porosity Material thickness 12mm $\le s \le$30mm	2012	A - the sum of the different pore areas related to the evaluation area: Wp x L	$A \le 3\%$ L = 100mm	$A \le 6\%$ L = 100mm	$A \le 15\%$ L = 100mm
2e	Uniformly distributed porosity Material thickness s > 30m	2012	A - the sum of the different pore areas related to the evaluation area: Wp x L	$A \le 4\%$ L = 100mm	$A \le 8\%$ L = 100mm	$A \le 20\%$ L = 100mm
3	Clustered (localized) porosity	2013	dA - maximum diameter of the clustered porosity	$dA \le$ 15mm or dA, max $\le Wp/2$	$dA \le$ 20mm or dA, max $\le Wp/2$	$dA \le$ 25mm or dA, max $\le Wp/2$
4	Linear porosity	2014	l - linear porosity length	Not permitted	Not permitted	$l \le$ 25mm
5	Elongated cavity and pipes (wormholes)	2016 2015	l - imperfection length	$l \le 0{,}2s$, but max. 3mm	$l \le 0{,}3s$, but max. 4mm	$l \le 0{,}4s$, but max. 6mm
6	Oxide inclusions	303	l - length of an inclusion s- nominal thickness of the butt weld	$l \le 0{,}2s$, but max. 3mm	$l \le 0{,}5s$, but max. 5mm	$l \le s$, but max. 10mm
7	Tungstan inclusions	3041	l - imperfection length	$l \le 0{,}2s$, but max. 3mm	$l \le 0{,}3s$ but max. 4mm	$l \le 0{,}4s$, but max. 6mm
8[2]	Lack of fusion	401	l - imperfection length	Not permitted	Not permitted	Permitted but only intermittent and not surfaced l < 25mm L = 100mm
9[2]	Lack of penetration	402	l - imperfection length	Not permitted	Permitted as applied to the double-sided welded joint	l < 25mm L = 100mm

					and not surfaced $l < 25$mm $L = 100$mm	

Symbols:

L - any (with imperfection maximum density) 100 mm weld length;

S - nominal thickness of the butt weld;

t – material thickness;

Wp - weld width.

[1] Quality levels 2 and 3 can have index «» which designates all imperfections above 25 mm and are not permitted.

[2] If the weld length is under 100mm the maximum imperfection length shall not be above 25 % of that length.

Note. The applicable ISO or EN standard may be applied along with the specified standard ДСТУ EN ISO 6520-1.

4. WELDING CONSUMABLES

4.1 GENERAL

4.1.1 Application.

4.1.1.1 The welding consumables intended for welding the structures specified in **1.1.1** shall be tested and approved by the Register. Based on the results of manufacturer survey and testing of welding consumables, the Register issues a Certificate of Approval for Welding Consumables, which is drawn up by the manufacturer's name and is subject to annual endorsement.

4.1.1.2 The requirements of this Section apply to the initial approval and annual endorsement of the Certificate of Approval for Welding Consumables, as well as the Certificate (C), regarding the welding consumables used for welding the normal, higher and high strength hull structural steels, corrosionresistant (stainless) steels and aluminium alloys.

This Section specifies the requirements for approval of the following categories of welding consumables:

covered electrodes for manual arc welding, and also for gravity and contact welding;

"wire - flux" combinations for submerged arc welding;

"wire - gas" combinations for gas-shielded metal arc welding (including tungsten inert gas welding - TIG, as well as plasma arc welding);

flux-cored wire with or without shielding gas for metal arc welding;

welding consumables for electrogas and electroslag welding.

4.1.2 Grading and designation.

4.1.2.1 General explanations.

Welding consumables are classified depending on their purpose, and also on the mechanical and chemical properties of the filler metal. Different grades or types of consumables may be used for specific applications or materials on a case-by-case basis.

The welding consumables covered by the requirements of this Section shall be classified using the basic and additional symbols given in **4.1.2.2 - 4.1.2.6**.

4.1.2.2 Welding consumables for welding normal and higher strength hull structural steels.

The welding consumables intended for welding the normal and higher strength hull structural steels, which meet the requirements of **3.2**, Part XIII "Materials", are divided into grades depending on the minimum yield stress of deposited metal or weld metal, and the impact test temperatures with the assignment of the basic symbols according to Table 4.1.2.2.

Table 4.1.2.2

Strength level of deposited metal or weld metal R_{eH}, MPa, min	Impact test temperature of deposited metal and weld metal specimens, ºC				
	+20	0	-20	-40	-60
305	1	2	3	4	–
375	1Y	2Y	3Y	4Y	5Y
400	–	2Y40	3Y40	4Y40	5Y40

4.1.2.3 Welding consumables for high strength steels.

The welding consumables intended for welding the high strength steels, which meet the requirements of **3.13**, Part XIII "Materials", are divided into grades depending on the minimum yield stress of deposited metal and the impact test temperatures of weld metal and deposited metal with the assignment of the basic symbols according to Table 4.1.2.3.

4.1.2.4 Welding consumables for corrosion-resistant (stainless) steels.

The welding consumables intended for welding the corrosion-resistant (stainless) steels, which meet the requirements of **3.16**, Part XIII "Materials", are divided into grades with the assignment of symbols M-1, MF-2, F-3, AM-4, A-5, A-6, A-7ss, AF-8dup, A-9sp and A-10sp according to the provisions in **4.8.1.2** considering the structure and composition of the steels to be welded. Additionally to the designation of the welding consumable grade, the symbol of a typical chemical composition (brand) of deposited metal shall be indicated similarly to **3.16.1.1**, Part XIII "Materials" for the base metal (refer also to **4.8.1.3**).

Table 4.1.2.3

Strength level of deposited metal $R_{p0,2}$ or R_{eH}, MPa, min	Impact test temperature for deposited metal and weld metal, ºC				
	+20	0	-20	-40	-60
420	-	-	3Y42	4Y42	5Y42
460			3Y46	4Y46	5Y46
500			3Y50	4Y50	5Y50
550			3Y55	4Y55	5Y55
620			3Y62	4Y62	5Y62
690			3Y69	4Y69	5Y69
890			3Y89	4Y89	-
960			3Y96	4Y96	-

4.1.2.5 Welding consumables for welding aluminium alloys.

The welding consumables intended for welding aluminium alloys, which meet the requirements of Section **5**, Part XIII "Materials", are divided into grades A, B, C and D (for international alloys) and 1, 2, 3 and 4 (for national alloys) in accordance with the provisions in **4.9.1.3** depending on the composition and strength level of the base metal used for approval tests. Initial letter W or R is placed before the grade symbol to designate the product type: wire or rod, respectively.

4.1.2.6 Additional symbols.

The following additional symbols, as applied to the welding consumables intended for welding the normal and higher strength hull structural steels, and also high strength steels, are used:

H15, H10 and H5 for controlled diffusible hydrogen content in the deposited metal as per **4.2.3**;

T - for approval of welding consumables for two-run welding technique, which provides welding in single run on each weld side without an additional back welding and gouging of the weld root;

M - for approval of welding consumables for multirun welding technique;

TM - for approval of welding consumables for two-run and multi-run welding technique;

S - for approval of welding consumables for semiautomatic welding technique;

SM - for approval of welding consumables for semiautomatic and automatic multi-run welding technique;

V - for approval of welding consumables for vertical welding with the forced weld formation using the electrogas and electroslag welding technique.

PW - for approval of welding consumables supplied with the confirmed mechanical properties of weld metal after heat treatment for stress relief.

4.1.3 Approval procedure.

4.1.3.1 Request for approval.

To approve welding consumables, a manufacturer shall submit to the Register a request for approval together with enclosed documents and specific information indicated in **4.3.1.3, 4.4.1.3, 4.5.1.5** and **4.6.1.4** relevant to the particular types of welding consumables.

4.1.3.2 Quality of manufacturing.

The manufacturer's production facilities, method of production and quality control of welding consumables shall be such as to ensure reasonable uniformity in manufacture.

The manufacturer shall ascertain this uniformity by means of analysis and systematic testing on each production batch.

In general, the welding consumables shall maintain the manufacturer-specified and secured characteristics (stated in the requirements for products acceptance) for a period of time of at least six months after the date of delivery, when properly stored and kept in the original packaging.

The consumables shall be supplied so packaged as to ensure compliance with the above requirement; the packaging shall be sufficiently strong to resist the usual transportation and handling operations.

The manufacturer shall mark (stamp or seal) each container or bag, as applicable, the markings which are necessary to trace back each production.

4.1.3.3 Surveys and tests.

The welding consumables are approved subject to satisfactory results of the following:

survey of the production potential and the quality assurance system of the manufacturer of welding consumables by the Surveyor to the Register;

tests of welding consumables to the extent of the initial approval as per **4.3** to **4.9** witnessed by the Surveyor to the Register directly at the manufacturer's or in the independent testing center recognized by the Register;

The scope of survey of the welding consumables manufacturers at the initial approval is established by the requirements of **5.2**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

The approval tests required shall be performed on samples of consumables representative of the production. Sampling procedures shall be agreed with the Surveyor to the Register.

In general, the approval tests consist of the following control checks and tests:

sampling inspection of the quality of product manufacture together with checking the welding and technological properties usually carried out during survey of production;

determination of the mechanical properties and chemical composition of deposited metal if the latter is specified by the technical documentation for manufacture and supply of products (coated electrodes, fluxcored wire);

determination of the mechanical properties of the butt welded joint metal;

determination of the content of diffusible hydrogen in deposited metal for the welding consumables with the relevant additional symbols (refer to **4.2.3.1**);

determination, where necessary, of the weld metal and welded joint susceptibility to hot cracking;

special types of tests relevant to the welding consumables for welding corrosion-resistant (stainless) steels according to **4.8**.

Unless otherwise specified, test specimens and procedure shall meet the requirements of this Section or Register-recognized standards.

In order to approve the welding consumables and welding processes, the requirements to which are not specified in the Rules, the scope of testing may comply with the standards recognized by the Register.

4.1.4 Issuance of the Certificate.

4.1.4.1 Upon satisfactory completion of the survey and tests required in this Section to the extent of the initial approval, the Register issues to a manufacturer the Certificate of Approval for Welding Consumables (COCM) of a set form.

4.1.5 Annual inspections and tests.

4.1.5.1 The Certificate of Approval for Welding Consumables is issued for a period of up to five years and is subject to annual re-approval surveys and tests carried out under the Register technical supervision. The re-approval surveys and tests shall be carried out at a yearly interval. The tests shall be completed by the end of each calendar year at the latest.

The scope of annual re-approval surveys of the welding consumables manufacturers is established by **5.2**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for the Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

The scope of annual re-approval surveys of the welding consumables is specified for particular types of the welding consumables and welding procedures as per **4.3.8.1, 4.4.4.1, 4.5.5.1, 4.6.5, 4.7.3, 4.8.5** and **4.9.3**.

4.1.5.2 In case re-approval tests show unsatisfactory results, the grade of welding consumables shall be lowered according to the actual values of the properties obtained. The approval may be resumed not before three months' period after the manufacturer has taken measures for production quality stabilization and performance of the tests for welding consumables upgrading in the established order.

4.1.5.3 Welding consumables approved by the Register on the basis of the test results conducted at the user's during the welding procedure approval shall be subjected to re-approval tests in the normal way either at the manufacturer's or, on its authorization, at the user's works.

4.1.5.4 Where conditions of re-approval are not met, the validity of the Certificate of Approval for Welding Consumables is ceased, and the welding consumables indicated therein may no longer be used for fabrication of the structures subject to survey by the Register.

Upon expiry the Certificate of Approval for Welding Consumables may be extended by the Register on the basis of the tests generally equivalent to the re-approval tests. Where the Certificate ceases to be valid ahead of time on the manufacturer's initiative, its extension requires testing to the extent agreed with the Register in each particular case.

In case the manufacturer has and maintains the quality system recognized by the Register, the Surveyor to the Register may not be present during the tests, provided they are conducted by the manufacturer in compliance with the quality control system in force at the manufacturer's and the test results are checked.

Note: The welding consumables manufacturer's quality system approval (certification) documents issued by the classification societies - IACS members, as well as by other competent bodies authorized in accordance with the national legislation or international agreements may be recognized by the Register after their review.

4.1.6 Manufacturer's responsibilities.

4.1.6.1 With the Register approval, the manufacturer assumes responsibility for ensuring that during fabrication the composition and properties of the products will conform to those of the tested welding consumables.

The manufacturer shall state in their catalogues and on packaging (label, tag) the information on the Register approval by indicating "Approved by the Register of Ukraine, ...” and specifying the grade of the welding consumable according to the Certificate of Approval for Welding Consumables. Besides, the information on storage conditions and use of welding consumables shall be indicated in the catalogue and on packaging.

The manufacturer shall keep up-to-date records of the manufacture of the approved consumables, including details of the history of the single productions and results of associated tests. The Register shall have free access to these records at all times.

The manufacturer is responsible for reporting to the Register any major modifications introduced in the production procedure for their further agreement with the Register.

The manufacturer takes on responsibility for full compliance with the all the requirements stated by the Register in connection with granting and renewing the Certificate of Approval for Welding Consumables.

4.1.7 Rights of the Register.

4.1.7.1 During validity of the Certificate of Approval for Welding Consumables the Register may require from the manufacturer to confirm the stable quality of raw material and finished product composition and properties, as well as adherence to the production process.

Where the production process, quality control and acceptance procedures change as well as where suppliers of raw materials and appropriate specifications, which may impair the quality of the welding consumables produced by the manufacturer, are substituted, the Register may require additional tests to be conducted by the manufacturer.

Where proofs exist of a welding consumable unsatisfactory quality, which have been obtained during its acceptance for fabrication of the structures subject to survey by the Register, the Certificate of Approval for Welding Consumables loses its validity and shall be withdrawn. The Register approval may be resumed only provided the manufacturer submits adequate proofs showing that factors causing the production poor quality have been eliminated and new re-approval tests have been carried out.

4.1.8 Special cases of approval of welding consumables.

4.1.8.1 Referred to special cases of approval of welding consumable are:

upgrading/uprating of welding consumables at manufacturer's request;

approval of welding consumables for compliance with international or national standards;

approval of welding consumables for compliance with the properties guaranteed by the manufacturer, which exceed or supplement the requirements of the Register Rules or appropriate standards;

approval of welding consumables fabricated under license or manufacturer's subsidiary companies;

approval of welding consumables based on the tests carried out in the course of approval by the Register of the welding procedures of the company using the welding consumables;

approval of welding consumables based on the results of the tests carried out by other classification societies or technical supervision authorities;

single permits for use of welding consumables having an approval of other classification societies or technical supervision authorities;

survey of the individual batches of welding consumables.

4.1.8.2 Tests on upgrading of welding consumables are carried out at the manufacturer's request and are generally combined with annual re-approval tests of the welding consumables. The scope of the tests for upgrading of welding consumables shall comply with the requirements in **4.3.8.2**, **4.4.4.2**, **4.5.5.2** and **4.6.3.**2 for the relevant types of welding consumables.

4.1.8.3 Welding consumables are generally approved by the Register for compliance with international or national standards in the following cases:

at the manufacturer's request;

in cases where requirements for welding consumables are not specially stated in the Register Rules.

In such cases, the scope and procedure of re-approval tests of the welding consumables shall meet the requirements of the appropriate standards.

4.1.8.4 Where welding consumables are approved by the Register for compliance with properties guaranteed by the manufacturer, which supplement or exceed the requirements of the Register Rules and/or appropriate standards, an adequate entry shall be made in the Certificate of Approval for Welding Consumables. The properties shall be confirmed by the test results.

4.1.8.5 When consumables of the same brand are manufactured in different workshops belonging to the same manufacturer, the complete series of tests is generally performed in one workshop only. In the other workshops (subsidiaries), upon agreement with the Register, a reduced test program equivalent to annual re-approval tests is permitted.

The manufacturer shall submit the data to the Register, which confirm that materials used in terms of their composition, fabrication process and welding characteristics are identical to those used in the main works.

However, shall there be any doubt, complete test series may be required by the Register.

The above requirements are also applicable to all manufacturers producing welding consumables under license.

If a unique powder flux is combined with different wires coming from several factories belonging to the same firm for a combination "wire - flux", the flux may be approved by the Register on the basis of testing the wire delivered by one of the suppliers, if all the suppliers produce and deliver the wires according to the same specification.

4.1.8.6 For approval of welding consumables on the basis of the tests of the welding procedures (refer to Section 6) the user of the welding consumables shall be authorized by the manufacturer to perform such works (combination of tests).

In this case the welding procedure approval test programme shall be extended and shall include the tests for determination of the deposited metal properties.

After receiving satisfactory test results, the Certificate for the particular batch is issued.

4.1.8.7 Where welding materials have approvals from other classification societies, the scope of tests to obtain the Register approval may be reduced to the annual programme required for the confirmation of the Certificate of Approval for Welding Consumables.

In such case, a copy of the detailed report on the tests performed shall be appended to the request for obtaining the Register approval.

The scope and results of the tests shall comply with the requirements of this Part.

4.1.8.8 The Register may issue a single permit for use of welding consumables that have been approved by other classification societies, but do not have the Certificate of Approval for Welding Consumables issued by the Register. Such permit is limited:

by the scope of the consumables used;

by use;

by time of use.

The Register reserves the right to require check tests of the welding consumables at the user's within the scope of tests for determination of the deposited metal properties, the results of which are presented in the form of the test report certified by the Register.

After receiving satisfactory test results, the Certificate for the particular batch is issued.

4.1.8.9 The single batches of welding consumables may be surveyed by the Register on the manufacturer or customer’s request as applied to the manufacturers holding the Certificate of Approval for Welding Consumables.

The survey may be carried out to confirm the conformity of a specific batch of products to the requirements related to:

the Register Rules for the relevant grade of welding consumables; standards for manufacture and acceptance of the given type of products;

additional requirements of the customer specified in the order for the products to be delivered.

4.2 GENERAL REQUIREMENTS FOR WELDING OF TEST ASSEMBLIES AND TESTS

4.2.1 Preparation and welding of test assemblies.

4.2.1.1 Base metal.

The base metal used for the test assemblies shall be of the steel grade appropriate to the welding consumables grade as specified in this Section.

For the preparation of all weld metal test assemblies any grade of structural steel may be used. When the chemical composition of welded metal is substantially different from the base metal, an overlay of side walls and backing strip may be carried out, as deemed necessary.

For the preparation of butt and tee assemblies, steel grades shall be chosen depending on the grade of welding consumables in compliance with the requirements of this Section.

If the welding consumable is intended for welding the steel of different grades, the butt assemblies shall be made of the highest grade steel.

The edge preparation shall be performed either by mechanical machining or by gas cutting with subsequent dressing with abrasive tools.

4.2.1.2 Welding conditions and type of current.

Welding conditions used for manufacture of test assemblies (amperage, voltage, travel speed, type of current and electrodes) shall be within the range recommended by the manufacturer for normal good welding practice.

Where it is stated that welding consumables are suitable for both alternating and direct current, alternating current shall be used for welding the test assemblies for mechanical tests. When samples for checking the operating characteristics of welding consumables are required, both types of current shall be generally used. When samples for hot cracking tests are required, direct current shall be used.

Type of current is identified with the following symbols and their combinations:

AC - alternating current;

DC+ - direct current electrode positive;

DC- — direct current electrode negative;

DC± - direct current electrodes positive and negative.

Post-weld heat treatment of the test assemblies is not allowed, where the consumables are approved for the as-welded condition only.

4.2.2 Mechanical tests.

4.2.2.1 Tensile tests:

.1 longitudinal cylindrical test specimens for tensile test.

For deposited metal test, the longitudinal cylindrical proportional test specimens shall be used according to Fig. 2.2.2.3 a), Part XIII "Materials" with dimensions: d = 10mm, L_0 = 50mm, L_c = 60mm, $R \geq$ 5mm.

The longitudinal axis of the test specimen shall coincide with the centre of the weld and:

the mid-thickness of the weld in the deposited metal test assemblies made following the multi-run procedure;

the mid-thickness of the 2nd run metal in the two-run butt welded assemblies.

The use of the fivefold longitudinal cylindrical test specimens of other diameters (more or less than 10 mm) is allowed according to **2.2.2.3**, Part XIII "Materials".

The specimens may be heated to a temperature not exceeding 250°C for 16 h for hydrogen removal prior to testing.

The yield stress, tensile strength and elongation shall be determined for each specimen, entered in a test report and shall meet the requirements established for specific grade of the welding consumable. The value of reduction in area shall also be determined and reported for information;

.2 transverse flat tensile test specimens.

For testing a butt welded joint, the transverse flat tensile test specimens with dimensions according to Fig. 4.2.2.1 and cut out perpendicularly to the longitudinal axis of the weld shall be used. The upper and lower surfaces of the weld shall be filed, ground or machined flush with the surface of the plate.

The tensile strength and fracture position shall be determined for each specimen, reported and comply with the requirements specified for specific grade of the welding consumable.

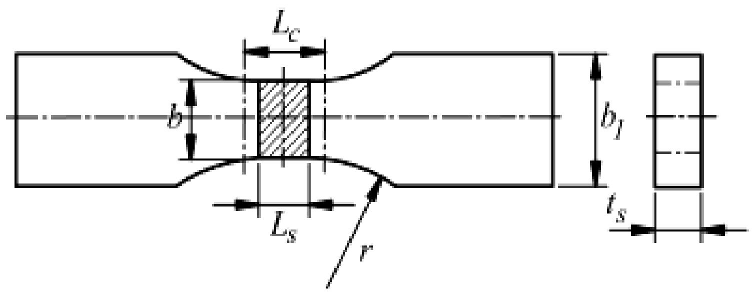


Fig. 4.2.2.1

L_s - greatest weld width after treatment (weld top); L_c = L_s + 60mm - parallel test length;

t_s - thickness of specimen with weld reinforcement removed;

b = 25mm - width of the parallel test length;

b_1 = b + 12mm - width of the specimen gripping part;

$r \geq$ 25mm - transition radius

4.2.2.2 Bend tests:

.1 transverse test specimens for weld root and face bend test.

For testing a butt welded joint, the transverse bend test specimens shall be made according to Fig. 2.2.5.1, Part XIII "Materials" and cut out perpendicularly to the longitudinal axis of the weld. The upper and lower surfaces of the weld shall be filed, ground or machined flush with the surface of the plate. The specimen corners in tension may be rounded to a radius not exceeding 2 mm.

If the test procedure allows for the bending of test specimen round the mandrel, then the test specimen length may exceed11a_0.

While tensile testing the transverse specimens, their weld face and root, the specimen dimensions shall be as follows:

$a_0 = t$ – metal plate thickness of the butt weld assembly,

b_0 = 30mm.

If the plate thickness (a_0) exceeds 25 mm, it may be reduced to this size by machining on the compression side of the test specimen.

The bend test specimens are tested in pairs: one specimen at a time for tensioning the weld root and face for the multi-run procedure or for tensioning on the side of the 1st and 2nd runs for the two-run procedure;

.2 transverse side bend test specimens.

The transverse side bend test specimens with dimensions:

a_0 = 10mm,

$b_0 = t$ – metal plate thickness of the butt weld test assembly,

shall be usually used in addition to or in lieu of weld root and face tensioning for approval of "wire-gas" combinations, and also for approval of electrogas and electroslag welding. In the latter case at the plate thickness $t \geq$ 40мм it is allowed to divide the specimen in two parts of the width $b_0 \geq$20mm.

.3 longitudinal bend test specimens.

The longitudinal bend test specimens shall be usually used in lieu of transverse specimens for approval of the welding consumables of grades A-9sp and A-10sp intended for welding heterogeneous joints according to **4.8.4.1**;

.4 requirements for test procedure.

Bend test results are considered satisfactory, when after bending through an angle of 120°, no cracks appear on the specimen surface being in tension. However, superficial cracks found on the specimen surface or open weld defects not exceeding 3 mm long shall be disregarded. The mandrel diameter is determined by the welding consumables grade and, for the materials intended for welding normal and higher strength hull structural steels is equal to three times the test specimen thickness.

4.2.2.3 Impact test.

The impact energy of the deposited metal and butt weld metal shall be determined on V-notch specimens meeting the requirements of **2.2.3**, Part XIII "Materials".

The sketch for cutting out the specimens from the test assemblies of the deposited metal and butt welded joint for impact testing shall allow positioning their longitudinal axis perpendicularly to the longitudinal axis of the weld and the fulfillment of the following requirements:

for deposited metal and butt welded test assemblies with multi-run technique, the specimens shall be taken at mid-thickness of the weld;

for butt welded test assemblies with two-run technique, the specimens shall be taken at a distance not exceeding 2 mm below the surface on the 2nd run side;

for electrogas and electroslag welded test assemblies, the specimens shall be taken from a butt welded test assembly at a distance not exceeding 2 mm below the surface.

The notch shall be cut in the face of the specimen perpendicular to the surface of the plate and to be positioned in the centre of the weld, and for electrogas and electroslag welding, an additional set of specimens with the notch at 2 mm from the fusion line in the weld metal shall be taken.

A set of three specimens shall be tested. The test temperature and the average impact energy shall meet the requirements specified for specific grade of welding consumables. The average impact energy for one of the specimens tested may be lower than required provided it is not lower than 70 % of this value.

4.2.3 Tests for checking diffusible hydrogen content in deposited metal.

4.2.3.1 The tests for checking diffusible hydrogen content in the deposited metal shall be carried out relative to the covered electrodes and flux-cored wire of the following grades:

2, 3 and 4, if applicable, (welding consumables may be classified according to **4.2.3.4**) in accordance with the application of the manufacturer;

2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40, as well as 5Y and 5Y40;

3Y (42/96), 4Y (42/96) and 5Y (42/69).

The requirements to conducting the tests and classification of the welding consumables depending on the hydrogen content, according to **4.2.3.4**, are also applicable for approval of the "wire - flux" combinations intended for welding:

high strength steels (refer to **4.7.4**);

higher strength steels relative to manufacture of MODU and FOP structures (refer to 2.5.4.3, Part XIII "Materials" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units (MODU) and Fixed Offshore Platforms (FOP).

Relative to the combination of "solid wire - gas" it is not necessary to conduct the tests and classification of welding consumables with respect to the diffusible hydrogen content according to **4.2.3.4**.

4.2.3.2 The following methods may be used to determine the content of diffusible hydrogen:

.1 the so-called mercury method standardized by ДСТУ EN ISO 3690 or the applicable ISO or EN standards and considered as the reference method, which requires degassing of the specimens in the mercury environment at the atmospheric pressure and at room temperature. The method is called "mercury" due to the sealing and manometer type fluid. The vacuum system used for the mercury method is used to prepare the installation for measurements as well as for preliminary drying (degassing) surface of the specimen;

.2 methods standardized by ДСТУ EN ISO 3690 or the applicable ISO or EN standards and based on degassing of the specimens in an inert carrier environment with the use of the thermal conductivity detectors (TCD) as instruments. These methods are also referred to as gas chromatographic because of the name of the equipment used to measure the amount of the precipitated hydrogen;

.3 vacuum methods based on degassing the specimens in vacuum at room temperature and providing results comparable to ДСТУ EN ISO 3690 or the applicable ISO or EN standards method. The amount of the precipitated gas can be determined by a liquid manometer or other types of manometers providing the required accuracy in the used measurement range;

.4 methods based on degassing the specimens and collecting the precipitated hydrogen in the glycerine environment at the normal pressure and temperature of 45°C. The selected test temperature is determined by viscosity-vs-temperature properties of glycerine as 45°C is the minimum temperature when free bubble can float up and build up a regular shape meniscus in the manometer tube used for gas volume measurement.

4.2.3.3 Determination of the content of diffusible hydrogen with the methods listed in **4.2.3.2** shall be carried out according to the requirements for the equipment, preparation to tests, performing the tests and processing test results as specified in **5.4.6**, Part III "Technical supervision during manufacture of materials" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships.

4.2.3.4 Depending on the determined content of diffusion hydrogen in the deposited metal, the welding consumables may be classified by the Register with assignment of classification notations H5, H10 or H15.

Individual and general average values of diffusible hydrogen content shall be submitted in the test reports. The method of determining the diffusion hydrogen content shall be specified in the test report.

The general average values for 4 specimens shall not exceed the values specified in Table 4.2.3.4.

Table 4.2.3.4

Classification notation by hydrogen content[1]	Content of diffusion hydrogen in the deposited metal when using the method, max. cm^3/100 g of deposited metal	
	ДСТУ EN ISO 3690[2]	Glycerine[3]
H15	15	15
H10	10	10
H5	5	Not applicable

[1] For very low hydrogen welding consumables, an additional notation 3 may be used to indicate an average value of diffusion hydrogen content max. 3,0 cm^3/100 g of deposited metal.

[2] Together with mercury and TCD (gas chromatographic) methods regulated by ДСТУ EN ISO 3690, diffusion hydrogen content may be determined using the vacuum method provided that all the requirements specified in **5.4.6**, Part III "Technical supervision during manufacture of materials" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships are met.

[3] If all the requirements to this test method as specified in **5.4.6**, Part III "Technical supervision during manufacture of materials" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships are met.

Note. The applicable ISO or EN standard may be applied along with the specified standard ДСТУ EN ISO 3690.

4.2.4 Hot cracking tests of welded joint.

4.2.4.1 Hot cracking tests of weld metal and welded joint shall be carried out by welding a tee-joint test assembly as shown in Fig. 4.2.4.1.

The number of test assemblies to be tested:

three assemblies for manual welding with covered electrodes;

one assembly for semiautomatic gas-shielded welding with a solid and flux-cored wire (for use with or without a shielding gas);

one assembly for manual and mechanized tungsten inert gas welding.

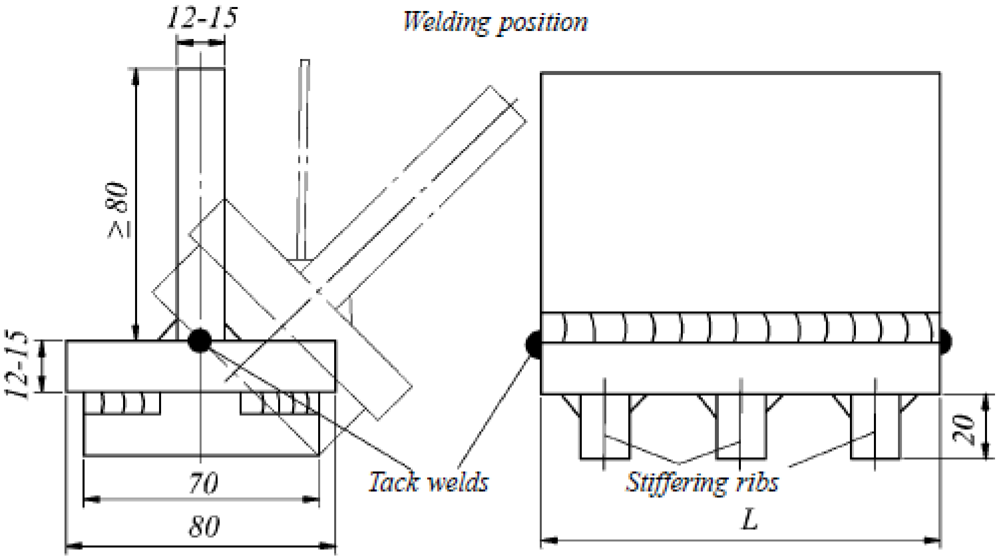


Fig. 4.2.4.1 Tee-joint test assembly for hot cracking test of welded joint
L = 120 mm - for manual welding with covered electrodes; *L* = 250 mm - for semiautomatic metal-arc electrode welding; *L* = 200 mm - for manual inert-gas tungsten-arc welding

Where possible, the test assemblies shall be welded using the filler materials of different diameters:

electrodes of 4 mm in diameter and of the maximum diameter to be approved;

welding wire of 1,2 mm in diameter for the "solid wire - gas" combinations and of the maximum diameter to be approved (generally 1,6 mm);

flux-cored wire for gas-shielded welding and flux-cored wire for use without shielding gas of 1,2 mm (or 1,4 mm) in diameter and of the maximum diameter to be approved (1,6 to 2,4 mm).

4.2.4.2 The butt edge of the vertical plate of a test assembly shall be smooth and fit closely to the lower plate surface. The gaps in a joint shall be eliminated before welding the test assembly. To match the test assembly, tack welds shall be made on the butt ends of the plates. The lower plate shall be stiffened by welding three transverse ribs with height approximately 20 mm (h=20) to protect it against deformation.

4.2.4.3 The tee-joint test assembly shall be welded in the downhand (gravity) position PA. The fillets shall be single-run welds joined at the maximum current recommended for the particular type and size of electrodes by the manufacturer.

The second fillet shall be welded immediately after the first one and shall end at that side of the test assembly where the first one was started. Both fillets shall be executed at a constant speed without weaving.

4.2.4.4 When welding a test assembly with covered electrodes (welding process 111), the length of each fillet (about 120 mm) shall correspond to that of the consumed part of the electrode according to Table 4.2.4.4-1.

Table 4.2.4.4-1

Diameter of electrode, mm	Consumed length of electrode, mm	
	1st weld	2nd (back) weld
4	200	150
5	150	100
6	100	75

When welding a tee-joint test assembly using the semiautomatic gas-shielded welding ("wire - gas" combination), the diameters of welding wire and the throat thickness shall be according to Table 4.2.4.4-2.

Table 4.2.4.4-2

Diameter of welding wire, mm	1st weld		2nd (back) weld	
	Effective throat thickness of fillet a, mm	Weld length L, mm	Effective throat thickness of fillet a, mm	Weld length L, mm
1,2	9	250	7	250
1,6	9	250	7	250

For welding with flux-cored wire, the relevant parameters for welding the test assembly shall be according to Table 4.2.4.4-3.

Table 4.2.4.4-3

Diameter of welding wire, mm	1st weld		2nd (back) weld	
	Effective throat thickness of fillet a, mm	Weld length L, mm	Effective throat thickness of fillet a, mm	Weld length L, mm
1,2 or 1,4	9	250	7	250
2,4[1]	10	250	9	250
[1] Or the maximum diameter to be approved.				

For inert gas welding of the test assembly with a tungsten electrode, the fillet dimensions shall approximately correspond to those when welding with covered electrodes of 4 to 5 mm in diameter.

4.2.4.5 After welding the test assembly and its complete cooling to the room temperature, slag and spatter shall be removed from the surface of the weld and affected zone, and the fillets shall be visually examined for surface cracks. In case the cracks are revealed, the test results are considered unsatisfactory and the further examination of the test assembly is not conducted. Upon satisfactory results of the examination for surface cracks, the test assembly examination shall be continued by fracture testing according to **4.2.4.6** or, upon agreement with the Register, by magnetic particle testing.

4.2.4.6 The fracture test of the tee-joint test assembly shall be conducted in compliance with the following requirements.

The first fillet shall be removed in a mechanical manner, and the second (back) one shall be tested for fracture with the failure to be positioned approximately in the middle of the fillet cross-section.

Note. During fracture testing, the test assembly of 250 mm in length shall be preliminary divided into three equal parts, and the test assembly of 200 mm in length, into two sections. The test assemblies of 120 mm in length shall be tested for fracture as a whole.

4.2.4.7 The fracture surface of the back weld shall be visually examined for intolerable defects. The examination shall be conducted with the naked eye and by means of 5X or 10X magnifying glass.

The welded joints, which have no cracks or intolerable defects on the fracture surface of back welds revealed in magnetic particle testing, are considered resistant to hot cracking.

4.2.5 Requirements for re-test procedures.

4.2.5.1 Tensile and bend tests.

Where the results of a tensile or bend test do not comply with the specified requirements, duplicate test specimens shall be prepared and tested. In case of the sufficient metal reserve, the specimens for re-test shall be taken from the test assembly used in the initial testing. Where insufficient original welded assembly is available, a new test assembly shall be prepared using welding consumables of the same batch. If the new assembly is made with the same welding procedure (in particular, the same number of layers and runs), only the duplicate re-test specimens need to be tested. Otherwise all test specimens shall be prepared for re-testing, including the duplicate test specimens failed in the initial testing.

In case the results of tests carried out on the duplicate test specimens are satisfactory, the welding consumable submitted to tests may be accepted.

If at least one specimen (from the additional ones) yields unsatisfactory results, the welding consumable submitted to tests shall be rejected.

4.2.5.2 Impact test.

The cases of unsatisfactory test results include: when the average value of three impact tests fails to meet the specified requirements;

or more than one result out of three is below the required average value;

or the result of any one of the specimens is more than by 30 % below the required average value.

In any of the above cases, re-tests may be conducted on the additional three specimens machined from the same test assembly if the sufficient metal reserve is available. At that the test results are considered satisfactory if the new average value of impact energy (three initial tests plus additional tests) exceeds the required average value and not more than two results out of six are below the required average value, and not more than one specimen has yielded the result, which is by 30 % below the required one.

When the test results for three initial and three additional specimens are unsatisfactory, the further tests shall be agreed with the Register. In this case a new test assembly shall be welded using the welding consumables of the same batch, and the test shall be conducted to the extent that shall include all the types of the tests provided for testing the first test assembly, as well as those with satisfactory results.

4.2.5.3 Hot cracking tests.

Where cracks are detected in the welded joint test assemblies being tested, the test results are considered unsatisfactory, and the welding consumables cannot be approved. Where isolated end crater cracks caused by the welder's poor skills are revealed, re-tests shall be performed with the same number of test assemblies after the relevant additional training of a welder in operating the welding consumables being tested.

4.3 COVERED ELECTRODES FOR MANUAL ARC WELDING OF NORMAL AND HIGHER STRENGTH HULL STRUCTURAL STEELS

4.3.1 General.

4.3.1.1 The following requirements apply to covered electrodes intended for the manual arc welding of normal and higher strength hull structural steels, steel forgings and castings of the corresponding strength grades, and of comparable steels intended for manufacturing ship's structures and pressure vessels. The number of test assemblies and specimens required is given in Table 4.3.1.1.

4.3.1.2 Covered electrodes are divided, for the various strength levels of the deposited metal (ReH, min), into the following grades:

1, 2, 3 and 4 for normal strength steels;

2Y, 3Y, 4Yand 5Y for higher strength steels with the specified yield stress of up to 355 MPa, inclusive;

2Y40, 3Y40, 4Y40 and 5Y40 for higher strength steels with the specified yield stress of up to 390 MPa, inclusive.

Depending on the diffusible hydrogen content in the deposited metal, symbols H15, H10 or H5 are added to the grade mark as per **4.2.3.4**.

4.3.1.3 A manufacturer shall submit for review the following information and technical documentation attached to the request for approval:

trade name of electrodes;

range of standard sizes (diameter, length) of the welding consumables to be approved;

type of electrode covering;

grade, for which the application is made, including additional symbols;

chemical composition (analytical tolerances) of the deposited metal;

weld metal recovery according to the relevant international and national standards;

welding technique and type of current;

proposed range of application and welding positions;

marking and packing; information on manufacturing capacity, facilities and quality control procedure;

instructions/recommendations for use;

information on the approvals granted by other classification societies or technical supervisory bodies, including copies of the required documents.

The technical documentation to be approved by the Register includes:

manufacturer's technical specifications or specifications for welding consumables, including the updated catalogues;

instructions for manufacture, acceptance and quality control.

Table 4.3.1.1

Test assembly						Number and type of specimens [2]
Type	Welding position [1]	Electrode diameter, mm	Number	Thickness, mm	Dimensions	
1	2	3	4	5	6	7
Deposited metal	PA	Ø 4mm	1	20	Fig. 4.3.2.1	1LT+3KV
		max Ø	1			
Butt weld	PA	1st run: Ø 4mm Intermediate: Ø 5mm Last two layers: max Ø	1	15 ÷ 20	Fig. 4.3.3.1	1TT+1RB+1FB+3KV
	PF	1st run: Ø 3,0 or Ø 3,25mm Remaining runs: Ø 4mm	1			1TT+1RB+1FB+3KV
	PC	1st run: Ø 4mm Remaining runs: Ø 5mm	1			1TT+1RB+1FB+3KV
	PE	1st run: Ø 3,0 or Ø 3,25mm Remaining runs: Ø 4m	1			1TT+1RB+1FB+3KV
Fillet weld	PB	1st side: min Ø	1	15 ÷ 20	Fig. 4.3.6.2	M+FF+HV
		2nd side: max Ø				

[1] Welding positions are designated according to ДСТУ ISO 6947 or the applicable ISO standard.
[2] The following abbreviations are used for the type of specimens:
LT - longitudinal cylindrical tensile test specimen;
TT - transverse flat tensile test specimen;
RB - transverse root bend test specimen;
FB - transverse face bend test specimen;
KV - transverse Charpy V-notch impact test specimen;
FF - fillet fracture test specimen;
M - transverse macrosection;
HV - hardness measurement specimen.

4.3.2 Tests of deposited metal.

4.3.2.1 Preparation of test assemblies. Two deposited metal test assemblies shall be welded in the flat position as shown in Fig. 4.3.2.1, one with 4 mm diameter electrodes and the other with the largest size manufactured. If the electrodes are available in one diameter only, one test assembly is sufficient.

Any grade of ship structural steel may be used for the preparation of the test assembly.

The weld metal shall be deposited in a single or multi-run layers according to normal practice to use electrodes (bead width), and the direction of deposition of each layer shall generally alternate from each end of the plate, each run of weld metal being not less than 2 mm and not more than 4 mm thick. Between each run the assembly shall be left in still air until it has cooled to less than 250°C, but not below 100°C the temperature being taken in the center of the weld on the surface of the seam. After being welded, the test assemblies shall not be subjected to any heat treatment.

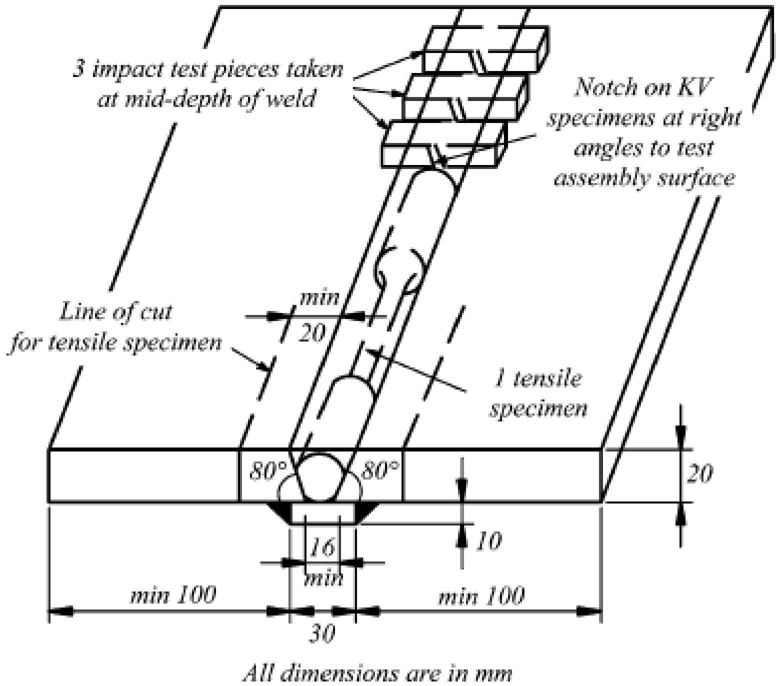


Fig. 4.3.2.1 Deposited metal test assembly when testing electrodes for manual arc welding (test specimens are designated according to Table 4.3.1.1).

4.3.2.2 Chemical analysis of deposited metal.

Test specimens shall be taken from each test assembly for chemical analysis of the deposited metal including the content of all alloying elements and impurities regulated by documentation for the product manufacture and acceptance control.

4.3.2.3 Test procedure.

One longitudinal tensile test specimen and three impact test specimens shall be taken from each test assembly according to Fig. 4.3.2.1. The specimen cutting-out, preparation and tests shall be performed in accordance with **4.2.2.1.1** and 4.2.2.3, respectively.

4.3.2.4 Requirements for test results. The results of all the tests shall meet the requirements in Table 4.3.2.4 for the relevant grades of welding consumables.

Table 4.3.2.4

Grade	Yield stress R_{eH}, MPa	Tensile strength R_m, MPa	Elongation A_5 ($L_0 = 5d$), min	Impact test	
				Test temperature, °C	Impact energy KV, J, min
1	305	400 ÷ 560	22	20	47
2				0	47
3				- 20	47
4				- 40	47
2Y	375	490 ÷ 660	22	0	47
3Y				-20	47
4Y				-40	47
5Y				-60	47
2Y40	400	510 ÷ 690	22	0	47
3Y40				-20	47
4Y40				-40	47
5Y40				-60	47

4.3.3 Tests of butt welded joint.

4.3.3.1 Preparation and manufacture of test assemblies.

To check the properties of a butt welded joint in each welding position (downhand, vertical-upward, vertical-downward, overhead and horizontal-vertical) for which the electrodes are approved, one test assembly shall be welded in each position. In this case the electrodes for welding in downhand and vertical-upward positions may be considered to meet the relevant requirements for welding in horizontalvertical position.

If the electrodes are approved for welding in downhand position only, two test assemblies shall be prepared in that position.

Depending on the grade of electrodes for preparing the welded joint test assemblies, the hull structural steel of one among the categories listed in Table 4.3.3.1 shall be used.

The copy of a certificate for the base metal for preparing the welded joint test assemblies shall supplement the test report.

Table 4.3.3.1

Electrode grade	Steel grade for test assembly [1]
1	A
2	A, B, D
3, 4	A, B, D, E
2Y	A32, A36, D32, D36
3Y	A32, A36, D32, D36, E32, E36
4Y, 5Y	A32, A36, D32, D36, E32, E36, F32, F36
2Y40	A40, D40
3Y40	A40, D40, E40
4Y40, 5Y40	A40, D40, E40, F40
[1] Фактичний тимчасовий опір R_m сталі категорій A32÷F32 повинний бути більшим 490 МПа.	

Butt weld test assemblies for electrode testing shall be as shown in Fig. 4.3.3.1.

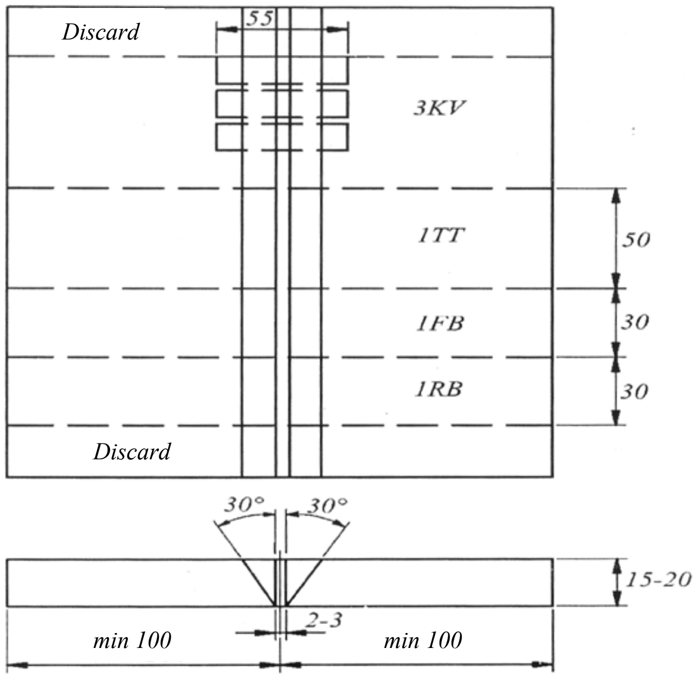


Рис. 4.3.3.1 tt weld test assembly when testing electrodes for manual arc welding (test specimens are designated according to Table 4.3.1.1. All dimensions are in mm)

4.3.3.2 Requirements for welding test assemblies.

The test assemblies for individual welding positions shall be welded as indicated below:

.1 downhand position - PA. One test specimen welded using 4 mm electrodes for the first run, 5 or 6 mm electrodes for intermediate runs (excluding the last two) in compliance with the normal practice of using electrodes. Electrodes of the maximum diameter to be approved for the last two runs;

.2 downhand position - PA (when the second downhand test is required). One test specimen welded using 4 mm electrodes for the first run, 5 mm electrodes for the second run, and electrodes of the maximum diameter to be approved for the remaining runs;

.3 horizontal position - PC. One test specimen welded using 4 mm or 5 mm electrodes for the first run, 5 mm electrodes for the remaining runs;

.4 vertical-upward and overhead positions – PF and PE, respectively. One test specimen welded using 3,0 (3,25) mm electrodes for the first run, 4 mm or possibly 5 mm electrodes, if recommended by the manufacturer for welding in the positions concerned for the remaining runs;

.5 vertical-downward position - PG. When the electrodes shall be used for vertical-downward welding, this procedure shall be used for preparation and welding of the test assembly using the electrodes of the diameter recommended by the manufacturer.

For all assemblies, the back sealing run shall be made with 4 mm diameter electrodes, in the welding position appropriate to each test specimen, after back gouging to sound metal. For electrodes suitable for downhand welding only, the test assemblies may be turned over to carry out the backing seal.

The test assembly shall be welded in compliance with the normal practice of using electrodes. Between each run the assembly shall be left in still air until it has cooled to less than 250°C, but not below 100°C. The temperature shall be measured in the center of the weld on the surface of the seam. After being welded, the test assemblies shall not be subjected to any heat treatment.

4.3.3.3 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test assemblies is recommended for detecting any internal defects.

4.3.3.4 Test procedure.

From each butt weld test assembly according to Fig. 4.3.3.1 shall be taken:

one transverse flat tensile test specimen;

three transverse V-notched impact test specimens;

one transverse root and one transverse face bend test specimen.

4.3.3.5 Requirements for test results.

The results of all tests shall meet the requirements of Table 4.3.3.5 for the relevant grades of welding consumables. The requirements for tests performance and results evaluation shall be in accordance with the provisions in **4.2**.

Table 4.3.3.5

Grade	Tensile strength R_m, (transverse specimens), MPa, min	Impact test		
		Test temperature, °C	Impact test	
			Downhand, horizontal-vertical and overhead	Vertical (upward and downward)
1	400	20	47	34
2		0	47	34
3		- 20	47	34
4		- 40	47	34
2Y	490	0	47	34
3Y		-20	47	34
4Y		-40	47	34
5Y		-60	47	34
2Y40	510	0	47	39
3Y40		-20	47	39
4Y40		-40	47	39
5Y40		-60	47	39

4.3.4 Hot cracking tests of welded joint.

4.3.4.1 Hot cracking tests of the weld metal and welded joint shall be carried out thief required by the Register according to **4.2.4**.

4.3.5 Tests for checking diffusible hydrogen content in deposited metal.

4.3.5.1 The tests for checking diffusible hydrogen content in the deposited metal shall be carried out in compliance with the provisions in **4.2.3** relative to the covered electrodes intended for welding the higher strength steels of categories: 2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40, and also 5Y and 5Y40.

Grade 2, 3 and 4 electrodes intended for welding normal strength steels may be classified for diffusible hydrogen content in the deposited metal as an option in accordance with the manufacturer's request.

The tests for checking diffusible hydrogen content in the deposited metal are generally conducted at the initial approval of welding consumables, and also if required by the Register during annual tests or on the manufacturer's request during upgrading tests.

4.3.6 Tests of electrodes for manual arc fillet welding.

4.3.6.1 Where the electrodes, according to the manufacturer's request, are submitted for approval for fillet welding only, and the scope of their testing to the full extent as per **4.3.3.1** cannot be applied, they shall be subjected to the following tests for the initial approval:

tee-joint testing according to **4.3.6.2** in all the welding positions, for which the electrodes shall be used;

checking of the deposited metal properties according to **4.3.2**;

checking of the diffusible hydrogen content in the deposited metal according to **4.3.5** and **4.2.3**.

When the electrodes are submitted for approval for both fillet and butt welding, the extent of additional tests (in addition to the general requirements for the test extent) for the initial approval may be limited to welding one tee-joint test assembly in the horizontal-vertical position (PB).

4.3.6.2 Tee-joint test assemblies shall be welded as per Fig. 4.3.6.2.

They shall be prepared in each welding position, for which the electrodes are intended (horizontal-vertical, vertical-upward, verticaldownward and overhead).

The test assemblies shall be welded with electrodes of the diameter recommended by the manufacturer for the welding position specified.

The test assembly length shall be sufficient to allow at least the deposition of the entire length of the electrode being tested. The first weld on the test assembly shall be made with the electrode of the maximum diameter manufactured, and the second one, with the electrode of the minimum diameter manufactured.

The fillet size is usually determined by the electrode diameter and welding current being recommended by the manufacturer for specific diameter and welding position.

The material for test assembly preparation shall comply with **4.3.3.1**.

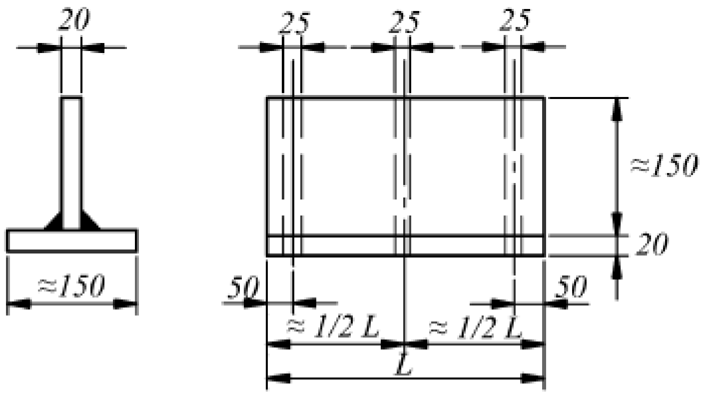


Fig. 4.3.6.2 Tee-joint assembly for testing electrodes for fillet welding.

4.3.6.3 Testing of tee-joint assembly:

.1 three macrosections of about 25 mm thick as shown in Fig. 4.6.3.2 shall be selected and prepared from three sections along each tee-joint test assembly. The macrosections shall be examined for root penetration, satisfactory weld profile and freedom from cracks, as well as from porosity and slags;

.2 the hardness of the weld metal, HAZ and base metal shall be measured on the macrosections as shown in Fig. 4.3.6.3.

The readings of the weld metal hardness on HV10 scale shall be the following:

≥ 120 HV for electrodes for welding the normal strength steel;

≥ 150 HV for electrodes for welding the higher strength steel with the yield stress $R_{eH} \leq$ 355MPa;

≥ 170 HV for electrodes for welding the higher strength steel with the yield stress 355 MPa < $R_{eH} \leq$ 390 MPa.

The hardness of the base metal and HAZ shall also be measured and reported;

.3 two remaining parts of the tee-joint assembly shall be subjected to fracture testing. One part is tested, after the removal of the first weld by mechanical gouging or with a chisel, by folding the plates together and tensioning the remaining weld root (refer to **6.3.4.4**). Another part is tested after the removal of the second weld by mechanical gouging or with a chisel. The fractured surfaces shall be examined for root penetration and freedom from cracks and significant porosity.

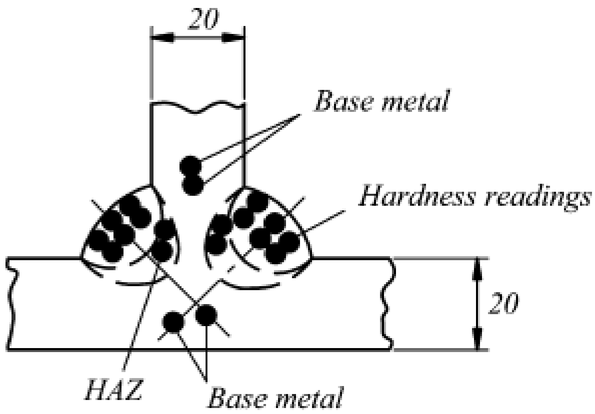


Fig. 4.3.6.3 Sketch of hardness readings on the macrosection of tee-joint assembly

4.3.7 Tests of electrodes for gravity and contact welding.

4.3.7.1 The electrodes approved only for gravity and contact welding, shall be subjected to the initial tests similar to those for manual electrodes:

deposited metal tests;

tee-joint tests (refer to **4.3.6**);

butt weld tests, where appropriate.

In so doing, additionally to the manual welding of test assemblies, the tests using the gravity and contact welding, according to the manufacturer's recommendations shall be carried out to the following extent:

tee-joint assembly tests (refer to **4.3.6**);

butt weld tests, where appropriate.

Where the electrodes for fillet welding are used for the gravity and contact welding, the tee-joint test assemblies shall be welded using the procedure recommended by the manufacturer and the longest size of electrode manufactured. In this case a report shall include the manufacturer's recommendations on the range of a welding current for each electrode size.

Where the approval is required for normal and higher strength steels, the higher strength steel shall be used for welding tee-joint and butt weld test assemblies.

4.3.8 Annual and upgrading tests.

4.3.8.1 Annual tests and re-approval surveys of the welding consumables manufacturers.

All the organizations recognized by the Register as electrode manufacturers shall be annually surveyed and their products shall be tested.

The annual tests shall, as a minimum, include the following:

.1 covered electrodes for standard manual arc welding.

The extent of annual testing of the electrodes intended for manual arc welding shall include the preparation of two deposited metal test assemblies according to **4.3.2**. The mechanical properties of the deposited metal (one longitudinal tensile test specimen and three impact test specimens from each test assembly) shall comply with the requirements of Table 4.3.2.4. The above mentioned is also applicable to the electrodes for fillet welding only.

If required by the Register, the tests may include the welding of a butt weld test assembly in a downhand or vertical position instead of the deposited metal test assembly for 4 mm electrodes. In this case the test extent may be limited to preparing three impact test specimens.

The extent of annual testing of the electrodes with the controlled diffusible hydrogen content and designated H10 and H5 may, on the Register's demand, include the test of welding consumables for the diffusible hydrogen content in the deposited metal according to **4.2.3**;

.2 covered electrodes for gravity and contact welding.

Where the electrodes are approved only for gravity and contact welding, the extent of annual testing shall include the welding of one deposited metal test assembly using the procedure recommended by the manufacturer. When these electrodes are also approved for standard manual arc welding, the annual tests shall be performed according to **4.3.8.1.1**.

4.3.8.2 Tests on electrode upgrading:

.1 tests on electrode upgrading are conducted only on the manufacturer's request and shall be preferably combined with the annual tests. Those tests usually need the preparation of butt weld test assemblies in addition to the standard annual tests;

.2 where the upgrading deals only with the change of a temperature when testing the impact test specimens without changing a strength group, only the additional tests of the impact test specimens made of the butt weld assemblies for each welding position specified in the Certificate of Approval for Welding Consumables shall be conducted at the changed temperature. These butt weld assemblies shall be tested in addition to two deposited metal test assemblies required for the usual annual tests (during which the impact tests of specimens are also conducted at the changed temperature);

.3 where the upgrading deals with the extension of the range of approval for welding the steels of a higher strength group, in addition to the standard extent of annual tests, the butt weld test assemblies shall be tested to the full extent according to **4.3.3**. In this case the steel for welding the butt weld test assemblies shall meet the requirements in **4.3.3.1** for upgraded welding consumables;

.4 tests for upgrading the electrodes approved for fillet welding only are carried out as follows:

in case the requirements only for the impact test temperature change, the deposited metal shall be tested at the temperature corresponding to the new grade (i.e. without extending the annual test scope);

in case the strength group of electrodes is revised, the tests shall be conducted to the full extent as required for the initial approval according to **4.3.6**.

4.4 "WIRE - FLUX" COMBINATIONS FOR SUBMERGED ARC WELDING

4.4.1 General.

4.4.1.1 The requirements given below apply to the "wire - flux" combinations for submerged arc welding of hull structural steels of normal and higher strength, steel forgings and castings of the relevant grades, and also comparable steels for the construction of ship's structures and pressure vessels.

The approval of welding consumables granted in accordance with these requirements is valid for standard single wire welding.

Other welding procedures like such as tandem and multi-wire welding, one-side welding on flux or ceramic backing shall be submitted to separate approval tests. These tests shall be generally carried out in accordance with the requirements given below by a separate program approved by the Register.

4.4.1.2 "Wire - flux" combinations depending on the strength level of the deposited or weld metal (R_{eH}, min) are divided into the following grades:

1, 2, 3 and 4 for normal strength steels;

1Y, 2Y, 3Y, 4Y and 5Y for higher strength steels with specified minimum yield stress up to 355 MPa, inclusive;

2Y40, 3Y40, 4Y40 and 5Y40 for higher strength steels with specified minimum yield stress up to 390 MPa, inclusive.

Depending on the welding procedure, the following symbols are added to the grade designation:

T - for welding consumables approved for a two-run technique;

M - for welding consumables approved for multi-run technique;

TM - for welding consumables approved for both techniques.

4.4.1.3 A manufacturer shall generally submit for review the information and technical documentation attached to the request for approval containing the following data:

commercial name of the flux, for which the approval is requested;

type of flux (fused or ceramic), typical analysis (or reference to the relevant normative document), type and size of granules (for fused fluxes);

commercial name of the associated wire, limits of chemical composition (or reference to the relevant normative document) and diameters to be approved;

producer, supplier, conditions under which it is supplied (surface protection, type, size and weight of the standard coils);

welding technique and grading, under which the approval is requested;

type of current and maximum current values, for which the approval is requested;

typical chemical composition of the deposited metal, with particular reference to the contents of Mn, Si and other alloying elements, which shall be specified in all cases;

conditions to which the chemical composition refers;

indications, where applicable, regarding the range of the welding parameters (current, voltage and welding speed);

information regarding the efficiency of "wire - flux" combination submitted for approval;

recommended edge preparation for various thicknesses;

recommendations and limitations on wire stick-out, if any;

packaging and labelling (marking);

information on manufacturer's workshops, manufacturing facilities, manufacturing and heat treatment cycles, methods and procedures of manufacturer's quality controls;

instructions and recommendations before using the flux (backing or hardening), as applicable;

previous approvals granted to the proposed "wire - flux" combination by other classification societies or supervisory bodies with copies of the required document attached.

The technical documentation to be approved by the Register:

manufacturer's technical specifications or specifications for a welding consumable, including the current catalogue editions;

instructions on the products manufacture, acceptance and quality control.

4.4.1.4 In the general case the number of test assemblies and specimens needed for the initial approval of welding consumables is given in Table 4.4.1.4. In this case a few preliminary specimens (assemblies) may be required by the Surveyor to the Register to be welded, in order to check the operating characteristics and set up the welding parameters.

Table 4.4.1.4

Welding technique	Test assembly				Number and type of specimens[1]
	Type	Number	Thickness, mm	Dimensions	
M	Deposited metal	1	20	Fig. 4.4.2.2.1	2LT+3KV
	Butt weld joint	1	20 ÷25	Fig. 4.4.2.3.1	2TT+2RB+2FB+3KV
T	Butt weld joint	1	12 ÷15	Fig.4.4.3.2.1 i Table 4.4.3.2.1	2TT+2TB+3KV
	Butt weld joint	1	20 ÷25		1LT+2TT+2TB+3KV
	Butt weld joint	1	30 ÷35		1LT+2TT+2TB+3KV
TM	[2]	[2]	[2]	[2]	[2]

[1]The following abbreviations are used for the type of specimens:
LT - longitudinal cylindrical tensile test specimen;
TT - transverse flat tensile test specimen;
RB - transverse root bend test specimen;
FB - transverse face bend test specimen;
TB - transverse side bend test specimen for a two-run technique;
KV - transverse Charpy V-notch impact test specimen.
[2] Test assemblies and tests of all types of specimens are required for both welding techniques; only one longitudinal tensile test (1TL) is required on the deposited metal test.

4.4.2 Multi-run technique (M).

4.4.2.1 General.

Where approval for use with multi-run technique is requested, the deposited weld metal and butt weld tests shall be carried out. The hull structural steel of any grade may be used for welding the deposited metal test assembly.

For preparing the butt weld test assembly, one of the hull structural steel grades given in Table 4.4.2.1, depending on the grade of the "wire - flux" combination to be approved, shall be used.

Table 4.4.2.1

"Wire-flux" combination grade	Test assembly steel grade[1]
1	A
2	A, B, D
3, 4	A, B, D, E
1Y	A32, A36
2Y	A32, A36, D32, D36
3Y	A32, A36, D32, D36, E32, E36
4Y, 5Y	A32, A36, D32, D36, E32, E36, F32, F36
2Y40	A40, D40
3Y40	A40, D40, E40
4Y40, 5Y40	A40, D40, E40, F40

[1] The actual tensile strength of grades 32 to F32 shall be greater than 490 MPa.

4.4.2.2 Deposited metal test.

4.4.2.2.1 Preparation of test assemblies. One deposited metal test assembly shall be welded in the downhand position, as shown in Fig. 4.4.2.2.1, in general with a wire having diameter of 4 mm.

The welding conditions (current, voltage and welding speed) shall be in accordance with the manufacturer's recommendations and conform with normal good welding practice.

The weld metal shall be deposited in multi-run layers consisting of one or several runs according to the normal practice. Direction of deposition of each layer shall, in general, alternate from each end of the plate. After completion of each run, the flux and welding slag shall be removed.

Between each run, the assembly shall be left in still air until it has cooled to less than 250°C, but not below 100°C. The temperature shall be taken in the centre of the weld on the surface of the seam. The thickness of each layer shall be neither less than the diameter of the wire nor less than 4 mm. After being welded, the test assemblies shall not be subjected to any heat treatment.

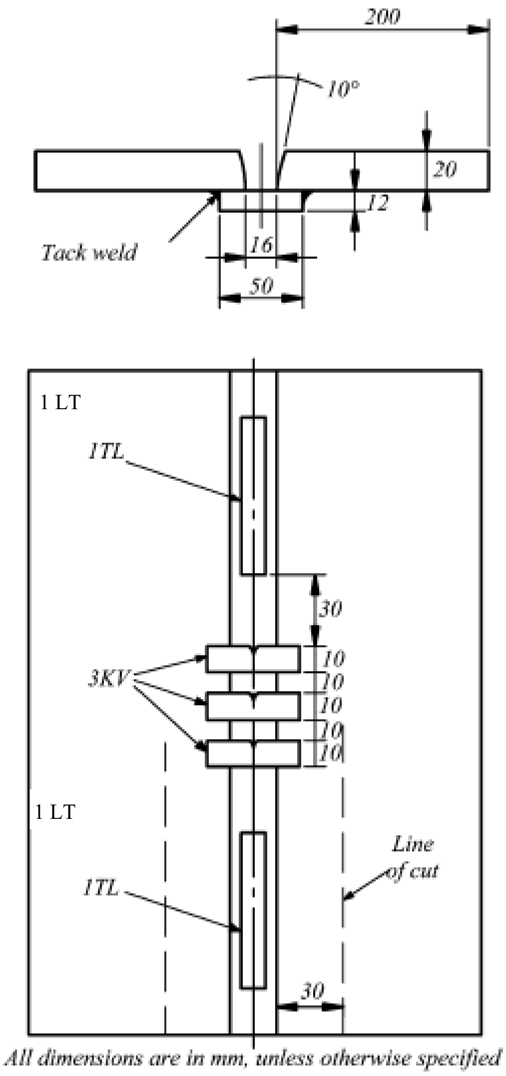


Fig. 4.4.2.2.1 Test assembly of deposited metal during testing of "wire _ flux" combinations (test specimens are designated according to Table 4.4.1.4)

4.4.2.2.2 Chemical analysis of deposited metal.

Test specimens shall be taken from each test assembly for chemical analysis of the deposited metal including the content of all alloying elements and impurities regulated by documentation for the product manufacture and acceptance control (as a rule, for ceramic fluxes).

4.4.2.2.3 Test procedure.

Two longitudinal tensile test specimens and three impact test specimens shall be taken from the test assembly as shown in Fig. 4.4.2.2.1. The specimens shall be cut out, prepared and tested according to **4.2.2.1.1** and **4.2.2.3**, respectively.

4.4.2.2.4 Requirements for test results.

The results of all tests shall comply with the requirements of Table 4.4.2.2.4 for corresponding welding consumable grades.

4.4.2.3 Butt weld test.

4.4.2.3.1 Preparation of test assembly.

One butt weld test assembly shall be welded in a downhand position, as shown in Fig. 4.4.2.3.1, in general with a wire having a diameter of 4 mm. The assembly length shall be sufficient for cutting out the specimens numbered and dimensioned as specified.

The welding shall be performed by the multi-run technique and the welding conditions shall be the same as those adopted for the deposited metal test assembly.

The back sealing run shall be made in a downhand position after back gouging to sound metal.

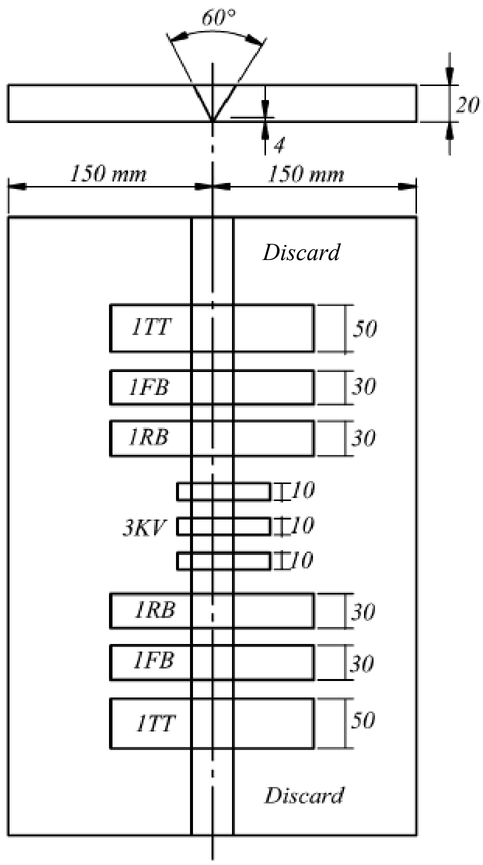
After being welded, the test assemblies shall not be subjected to any heat treatment.

4.4.2.3.2 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic inspection of butt weld test assemblies is recommended to ascertain if there are any defects.

Table 4.4.2.2.4

Grade	Yield stress, R_{eH}, MPa, min	Tensile strength, R_m, MPa	Elongation A_5 ($L_0 = 5d$), min	Impact test	
				Test temperature, °C	Impact energy KV, J, min
1	305	400 ÷ 560	22	20	34
2				0	34
3				- 20	34
4				- 40	34
2Y	375	490 ÷ 660	22	20	34
3Y				0	34
4Y				-40	34
5Y				-60	34
2Y40	400	510 ÷ 690	22	0	39
3Y40				-20	39
4Y40				-40	39
5Y40				-60	39



All dimensions are in mm, unless otherwise specified

Fig. 4.4.2.3.1 Butt weld test assembly in testing "wire-flux" combinations for multi-run technique (test specimens are designated according to Table 4.4.1.4)

4.4.2.3.3 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic inspection of butt weld test assemblies is recommended to ascertain if there are any defects.

4.4.2.3.3 Testing.

The test specimens as shown in Fig. 4.4.2.3.1 and in accordance with Table 4.4.1.4, shall be taken from each butt weld test assembly:

two transverse flat tensile test specimens;

three transverse V-notched impact test specimens;

two transverse root and two transverse face bend test specimens.

4.4.2.3.4 Requirements for test results.

The results of all tests shall comply with the requirements in Table 4.4.2.3.4 for the relevant welding consumable grades.

The requirements for testing and results evaluation shall comply with the requirements in **4.2**.

Table 4.4.2.3.4

Grade	Yield stress (transverse specimen) R_m, MPa	Impact test	
		Test temperature, °C	Impact energy KV, J, min
1	2	3	4
1	400	20	34
2		0	34
3		- 20	34
4		- 40	34
2Y	490	20	34
3Y		0	34
4Y		-40	34
5Y		-60	34
2Y40	510	0	39
3Y40		-20	39

4Y40		-40	39
5Y40		-60	39

4.4.3 Two-run technique (T).

4.4.3.1 Number of test assemblies and general requirements. Where the "wire - flux" combination approval for use with two-run technique only is requested, two butt weld test assemblies of the base metal thickness within the ranges below depending on the "wire-flux" combination grade shall be prepared:

for grades 1 and 1Y: 12 - 15 mm and 20 - 25 mm;

for grades 2, 2Y, 3, 3Y, 4, 4Y,5Y: 20 - 25 mm and 30 - 35 mm;

for grades 2Y40, 3Y40, 4Y40, 5Y40: 20 - 25 mm and 30 - 35 mm.

In this case deposited metal testing is not required, and the test extent is limited to testing two butt weld test assemblies according to **4.4.3.2**.

A limitation of approval to the lower and medium thickness range (up to the maximum welded plate thickness) may be agreed with the Register, and then the test assemblies shall be welded from the plates of a thickness of 12 - 15 mm and 20 - 25 mm, irrespective of the quality grade, for which the combination approval is required.

Where approval is required for welding normal and higher strength steels, two test assemblies of higher strength steel shall be welded. In this case the Register may demand additional testing of two butt weld test assemblies of normal strength steel.

4.4.3.2 Butt weld test.

4.4.3.2.1 Preparation and manufacture of test assemblies.

The preparation of butt weld test assemblies to approve the two-run welding technique, including the maximum welding wire diameter, steel grades for preparing the test assemblies and details of edge preparation, shall be carried out according to Table 4.4.3.2.1. The test assemblies shall be dimensioned as shown in Fig. 4.4.3.2.1 and allow cutting out the specimens numbered and dimensioned as specified.

Some minor deviations in the edge preparation are allowed, if recommended by the manufacturer. A joint gap shall not exceed 1 mm.

Each butt joint shall be welded in two runs, one from each side. Welding conditions (amperage, voltage and travel speed) shall be within the range recommended by the manufacturer for normal good two-run welding practice.

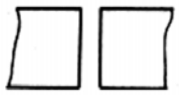
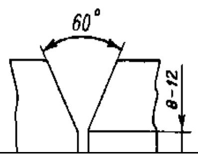
After the completion of the first run, the flux and welding slag shall be removed and the test assembly left in still air until it has cooled to 100°C, the temperature being taken in the centre of the weld, on the surface of the seam.

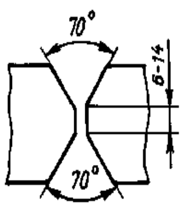
After being welded, the test assemblies shall not be subjected to any heat treatment.

4.4.3.2.2 Radiographic testing.

Prior to the preparation of test specimens for mechanical testing, the butt weld test assemblies shall be subjected to radiographic testing to detect any internal defects.

Table 4.4.3.2.1

Test assembly thickness, mm	Edge preparation recommended, mm	Wire diameter, mm, max	Combination grade	Steel grade	
				Grade of normal strength steel	Grade of higher strength steel[1]
1	2	3	4	5	6
12–15		5	1 1Y	A –	– A32, A36
20–25		6	1 1Y	A –	– A32, A36
			2 2Y 2Y40	A, B or D – –	– A32, A36, D32, D36 A40, D40

			3, 4 3Y 3Y40 4Y, 5Y 4Y40, 5Y40	A, B, D, E – – – –	– A32, A36, D32, D36, E32, E36 A40, D40, E40 A32, A36, D32, D36, E32, E36, F32, F36 A40, D40, E40, F40
30–35		7	2 2Y 2Y40	A, B or D – –	– A32, A36, D32, D36 A40, D40
			3, 4 3Y 3Y40 4Y, 5Y 4Y40, 5Y40	A, B, D, E – – – –	– A32, A36, D32, D36, E32, E36 A40, D40, E40 A32, A36, D32, D36, E32, E36, F32, F36 A40, D40, E40, F40
[1] The actual tensile strength of A32 to F32 grade steels shall be above 490 MPa.					

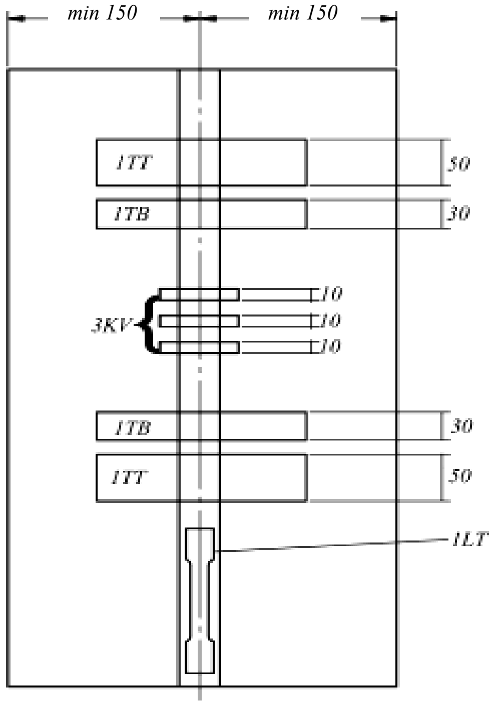
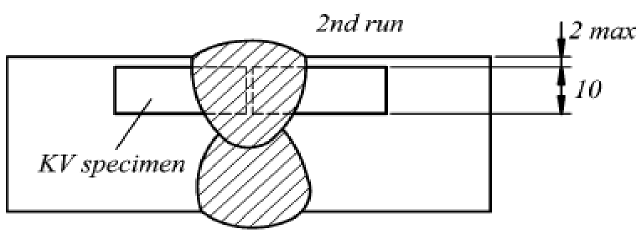


Fig. 4.4.3.2.1 Butt weld test assembly during testing "wire - flux" combinations for two-run welding technique (test specimens are designated according to Table 4.4.1.4. All dimensions in mm.)

4.4.3.2.3 Test procedure.

As shown in Fig. 4.4.3.2.1 and in accordance with Table 4.4.1.4, the test specimens, which type and number correspond to the assembly thickness, shall be taken from each butt weld test assembly.

The notch orientation and position on the impact test specimens shall be as shown in Fig. 4.4.3.2.3.



All dimensions are in mm, unless otherwise specified

Fig. 4.4.3.2.3 Arrangements for cutting of impact bending specimens to test butt welds made according to the twopass welding technique (designations of test assemblies shall comply with Table 4.4.1.4)

4.4.3.2.4 Requirements for test results.

The results of all tests shall meet the requirements in Table 4.4.2.2.4 for longitudinal cylindrical tensile specimens and in Table 4.4.2.3.4 for the other types of specimens in accordance with the grade of the welding consumables to be approved.

The requirements for test procedure and results evaluation shall meet the requirements in **4.2**.

4.4.3.2.5 Chemical analysis of deposited metal.

Test specimens shall be taken from each test assembly for chemical analysis of the deposited metal including the content of all alloying elements and impurities regulated by documentation for the product manufacture and acceptance control (as a rule for ceramic fluxes).

4.4.4 Annual and upgrading tests.

4.4.4.1 Annual tests and re-approval surveys of the welding consumables manufacturers.

All the organizations recognized by the Register as welding consumable manufacturers to be used in "wire - flux" combinations shall be annually surveyed and their products shall be tested.

The annual tests shall, as a minimum, include the following:

.1 "wire - flux" combinations for multi-run welding technique.

The extent of the annual tests for the "wire - flux" combinations for the multi-run welding technique shall include the preparation and tests of one deposited metal test assembly according to **4.4.2.2**. One longitudinal tensile test specimen and three impact test specimens shall be tested, and the test results shall meet the requirements in Table 4.4.2.2.4;

.2 "wire - flux" combinations for two-run welding technique.

The extent of the annual tests for the "wire - flux" combinations for the two-run welding technique shall include the preparation and tests of one butt weld test assembly of at least 20 mm thick according to **4.4.3.2**. One transverse tensile test specimen, two transverse bend test specimens and three impact test specimens shall be tested. In this case, where the combination shall be approved for the two-run welding technique only, one longitudinal cylindrical tensile test specimen shall be tested as well. The test results shall meet the requirements of 4 **4.4.3.2.4**;

.3 "wire - flux" combinations for multi-run and two-run welding techniques.

The extent of the annual tests for the "wire - flux" combinations for the multi-run and two-run welding techniques shall include the preparation and tests of a deposited metal test assembly and a butt weld test assembly of at least 20 mm thick according to **4.4.4.1.1** and **4.4.4.1.2**, respectively. In this case the preparation and test of a longitudinal cylindrical tensile test specimen from the butt weld test assembly are not required.

If the combination is approved for welding normal and higher strength steels, a butt weld test assembly of higher strength steel shall be prepared and tested according to **4.4.4.1.2**.

4.4.4.2 Upgrading tests.

4.4.4.2.1 Where the upgrading deals only with the change of a temperature when testing the impact test specimens without changing a strength group, only the additional tests of three impact test specimens made of the butt weld assembly prepared as per **4.4.2.3** for a multi-run welding technique or according to **4.4.3.2** for the base metal of the approved maximum thickness as applied to the two-run welding technique, shall be conducted at that changed temperature. These butt weld test assemblies shall be tested in addition to the extent of the annual tests according to **4.4.4.1** (for which impact test specimens are also tested at the changed temperature).

4.4.4.2.2 Where the upgrading deals with the extension of the range of approval to cover the welding of higher strength level steels, the butt weld test assemblies shall be tested to the full extent according to **4.4.2.3** or **4.4.3.2** in addition to the usual extent of annual testing. In this case the steel for preparing the butt weld assemblies shall meet the requirements in **4.4.2.1** or **4.4.3.2.1** (for multi-run and two-run techniques, respectively) for the new higher grade of welding consumables.

4.5 WIRE AND "WIRE - GAS" COMBINATIONS FOR SHIELDED METAL ARC WELDING

4.5.1 General.

4.5.1.1 The requirements given below apply to "wire - gas" combinations, and also to flux-cored wire (for welding with and without shielding gases), which are intended for semiautomatic and automatic welding of normal and higher strength hull structural steels, steel forgings and castings of the relevant grades, and also comparable steels for the construction of ship's structures and pressure vessels.

As applied to an approval procedure, the welding consumables in question are divided into the following groups:

for use in semiautomatic multi-run welding;

for use in single-electrode automatic multi-run welding;

for use in single-electrode automatic two-run welding.

Note. The terms "manual", "semiautomatic" and "automatic" welding in this Part of the Rules are used to designate the following degrees of the welding process mechanization:

manual welding means a process wherein all operations are carried out manually by a welder;

semiautomatic welding means a process wherein the filler metal feed is mechanized while other operations are carried out manually by a welder. According to ДСТУ 3761.2 and ISO/TR 25901-3 , this process is defined as "partially mechanized welding";

automatic welding means a process wherein all main operations, except the product movement, are mechanized. According to ДСТУ 3761.2 and ISO/TR 25901-3, this process is defined as "fully mechanized welding".

The approval of welding consumables granted in accordance with these requirements is valid for the standard single-wire welding.

Other welding procedures such as tandem and multi-wire welding, one-side welding on flux or ceramic backing shall be submitted to separate approval tests. These tests shall be generally carried out in accordance with the requirements given below by a separate program approved by the Register.

4.5.1.2 The "wire - gas" combinations depending on the strength level of the deposited or weld metal (R_{eH}, min) are divided into the following grades:

1, 2, 3 and 4 for normal strength steels;

1Y, 2Y, 3Y, 4Y and 5Y for higher strength steels with the specified minimum yield stress of up to 355 MPa, inclusive;

2Y40, 3Y40, 4Y40 and 5Y40 for higher strength steels with the specified minimum yield stress of up to 390 MPa inclusive.

Depending on the welding procedure, the following symbols are added to the grade designation:

S - for welding consumables approved for semiautomatic multi-run technique;

T - for welding consumables approved for automatic two-run technique;

M - for welding consumables approved for automatic multi-run technique;

TM - for welding consumables approved for both techniques.

For welding consumables approved for semiautomatic and automatic multi-run techniques, the additional symbols shall be added in the combination as appropriate (SM).

Additional symbols H15, H10 or H5 according to **4.5.1.4** are used to designate the grade depending on the diffusible hydrogen content in the deposited metal as applied to a flux-cored wire.

4.5.1.3 Shielding gas composition:

.1 composition of the shielding gas used in approval testing shall be given in the test report and Certificate of Approval for Welding Consumables/Certificate (C). Unless otherwise agreed with the Register, the use of the shielding gas of another composition for the same wire requires additional approval testing;

.2 approval of welding wire in combination with any specific gas composition may be applied to, and extended over, the combinations of this wire with the shielding gases of the similar group of a typical mixture to be determined according to Table4.5.1.3.2.

Table 4.5.1.3.2

Group of shielding gas mixture		Composition of gas mixtures in volume, % об.			
		CO_2	O_2	H_2	Ar
M1	1	> 0 ÷ 5	–	> 0 ÷ 5	Base[1, 2]
	2	> 0 ÷ 5	–	–	Base[1, 2]
	3	–	> 0 ÷ 3	–	Base[1, 2]
	4	> 0 ÷ 5	> 0 ÷ 3	–	Base[1, 2]
M2	1	> 5 ÷ 25	–	–	Base[1, 2]
	2	–	> 3 ÷ 10	–	Base[1, 2]
	3	> 5 ÷ 25	> 0 ÷ 8	–	Base[1, 2]
M3	1	> 25 ÷ 50	–	–	Base[1, 2]
	2	–	> 10 ÷ 15	–	Base[1, 2]
	3	> 5 ÷ 50	> 8 ÷ 15	–	Base[1, 2]
C	1	100	–	–	–
	2	Base	> 0 ÷ 3	–	–

[1] Argon may be replaced by helium up to 95 % of the argon content.
[2] Approval covers only the gas mixtures with a similar or higher helium content.

4.5.1.4 Setting of diffusible hydrogen content:

.1 tests for checking diffusible hydrogen content in the deposited metal shall be conducted relevant to the flux-cored wire intended for welding with or without shielding gas for the following grades of welding consumables:

2, 3 and 4, if applicable (consumables may be graded according to **4.2.3.4**) in accordance with the manufacturer's request;

1Y, 2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40, as well as 5Y and 5Y40.

The tests are carried out as per **4.2.3** under the welding conditions recommended by the manufacturer at a welding speed providing mass of the metal deposited on a specimen similar in value to that for testing the electrodes (15 to 20 g per 100 mm of the weld);

.2 on the basis of the test results obtained and requirements in **4.2.3.4**, the symbols H15, H10 or H5 featuring the diffusible hydrogen content in the deposited metal shall be added to the designation of the combination grade according to **4.5.1.2**.

4.5.1.5 Information and documentation to be submitted for review.

A manufacturer shall generally submit for review the information and technical documentation attached to the request for approval containing the following data:

commercial name, type of welding wire, limits of chemical composition in the case of bare wires and information on additives in the case of flux-cored wires (or reference to a relevant normative document), and range of wire diameters to be approved;

producer, supplier, conditions of supply (surface condition, type, diameters and weight of standard coils);

welding technique and grading, under which the approval is requested;

type of current, welding positions and range of current, for which the approval is requested;

properties, composition and requirements relevant to the shielding gas or gas mixture;

commercial brand and a manufacturer, in the case of gas mixtures of special types;

typical chemical composition of the deposited metal, with particular reference to the contents of Mn, Si and other alloying elements, which shall be specified in all cases;

conditions to which the chemical composition refers;

main operating characteristics and welding techniques (such as spray arc, short arc or dip transfer), associated recommendations and limitations;

packaging and labelling (marking);

manufacturer's workshop, manufacturing facilities, manufacturing and treatment cycles, methods and procedures of manufacturer's quality controls;

recommendations for storing and preservation of flux-cored and coated wires;

information on the approval granted by other classification societies or technical supervisory bodies with copies of the required document attached.

The technical documentation to be approved by the Register:

manufacturer's technical specifications or specifications for welding consumables, including the current catalogue editions;

instructions on the products manufacture, acceptance and quality control.

4.5.2 Welding wire and "wire - gas" combinations for semiautomatic multi-run welding.

4.5.2.1 General requirements.

The approval test relevant to semiautomatic multi-run welding shall be conducted according to **4.3** using the flux-cored wire or "wire - flux" combinations for welding the test assemblies. The number of test assemblies and test specimens required is given in Table 4.5.2.1.

Table 4.5.2.1

Test assembly						Number and type of specimens[2]
Type	Welding position[1,2]	Electrode diameter, mm	Number	Thickness, mm	Dimensions	
Deposited metal	PA	1,2 or min Ø	1	20	Fig. 4.3.2.1	1TL+3KV
		max Ø	1[4]			
Butt weld	PA	1st run: 1,2 or min Ø Remaining runs: max Ø	1[5]	15 ÷ 20	Fig. 4.3.3.1	1TT+1RB+1FB+3KV
	PF	1st run: 1,2 or min Ø	1			1TT+1RB+1FB+3KV
	PC	Remaining runs: max Ø for	1			1TT+1RB+1FB+3KV

	PE	specific position	1			1TT+1RB+1FB+3KV
Fillet weld	[6]	1st side: min Ø 2nd side: max Ø	1	15 ÷ 20	Fig. 4.3.6.2 i 4.3.6.3	M+FF+HV

[1] Welding positions are designated according to ДСТУ ISO 6947 or the applicable ISO standard (refer to Fig. 6.2.2.4-1).

[2] When the approval is requested only for one or limited number of welding positions, the butt weld test assemblies shall be welded in such positions only.

[3] The following abbreviations are used for the type of specimens:

TL - longitudinal cylindrical tensile test specimen;
TT - transverse flat tensile test specimen;
RB - transverse root bend test specimen;
FB - transverse face bend test specimen;
KV - transverse Charpy V-notch impact test specimen;
FF - fillet fracture test specimen;
M - transverse macrosection;
HV - hardness measurement specimen.

[4] When the approval is requested only for one diameter, only one deposited metal test assembly shall be prepared.

[5] When the approval is requested for a downhand welding position only, two test assemblies shall be prepared in this position: one using the largest diameter wire, and another using the wire of an increasing diameter from the first to the last run.

[6] Fillet weld test assemblies shall be welded in the position required for approval.

4.5.2.2 Deposited metal test.

4.5.2.2.1 Preparation and manufacture of test assembly.

Two deposited metal test assemblies shall be welded in a downhand position as shown in Fig. 4.3.2.1, one using a wire of 1,2 mm or the smallest size, and the other using a wire of the largest size intended for welding hull structures. If only one diameter is available, one test assembly is sufficient. Any grade of hull structural steel may be used for the preparation of the test assembly.

The weld metal is deposited in multi-run layers according to the manufacturer's recommendations and the normal practice, and the direction of deposition of each layer shall, in general, alternate from each end of the plate. Each weld bead shall be within 2 mm to 6 mm thick. Between each run the assembly shall be left in still air until it has cooled to less than 250°C, but not below 100°C, the temperature being taken in the centre of the weld on the surface of the seam. After being welded, the test assemblies shall not be subjected to any heat treatment.

4.5.2.2.2 Chemical analysis of deposited metal.

Test specimens shall be taken from each test assembly for chemical analysis of the deposited metal including the content of all alloying elements and impurities regulated by documentation for the product manufacture and acceptance control (as a rule, for flux-cored wire).

4.5.2.2.3 Mechanical tests.

One longitudinal tensile test specimen and three impact test specimens shall be taken from each test assembly according to Table 4.5.2.1 and Fig. 4.3.2.1. The specimens shall be cut out, prepared and tested according to the instructions in **4.2.2.1.1** and **4.2.2.3**, respectively.

The results of all tests shall comply with the requirements of Table 4.3.2.4 for the corresponding welding consumable grade.

4.5.2.3 Випробування стикового зварного з'єднання.

4.5.2.3.1 Butt weld test.

4.5.2.3.1 Preparation and manufacture of test assemblies.

To check the properties of a butt welded joint in each welding position (downhand, horizontal, vertical upwards and downwards and overhead) for which the "wire-gas" combination shall be approved, one test assembly as shown in Fig. 4.3.3.1 shall be welded in each position.

The hull structural steel of one of the grades in Table 4.3.3.1 shall be used for preparing the assemblies.

The test assemblies for individual welding positions shall be welded as indicated below:

downhand position - PA. One test specimen welded using a wire of 1,2 mm or the minimum diameter to be approved for the first run and a wire of the maximum diameter to be approved for the remaining runs;

where approval is requested for a downhand welding position only, two test assemblies shall be welded in that position: the first using a wire of the maximum diameter, and the second using the wire of an increasing diameter from the first to the last run. When the wire of one diameter is available, one test assembly shall be prepared;

welding positions other than the downhand one (PC, PE, PF and PG). One test specimen welded using a wire of 1,2 mm or the minimum diameter to be approved for the first run and a wire of the maximum diameter recommended by a manufacturer for a specific welding position for the remaining runs.

After being welded, the test assemblies shall not be subjected to any heat treatment.

4.5.2.3.2 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test assemblies is recommended for detecting any internal defects.

4.5.2.3.3 Mechanical tests.

As shown in Fig. 4.3.3.1 and in accordance with Table 4.5.2.1, from each butt weld test assembly the following specimens shall be taken:

one transverse flat tensile test specimen;

three transverse V-notched impact test specimens;

one transverse root and one transverse face static bend test specimens.

The results of all tests shall comply with the requirements in Table 4.3.3.5 for the relevant welding consumable grades. The requirements for test procedure and their results evaluation shall meet the requirements in **4.2**.

4.5.2.4 Tee-joint weld test.

The tee-joint weld test is required for the "wire - gas" combinations intended for fillet welding only and is conducted similarly to the requirements in **4.3.6** for the covered electrodes. Test assemblies shall be manufactured in the welding positions to be approved according to **4.3.6.2**. The test extent and results shall comply with the requirements in **4.3.6.3**.

4.5.2.5 Tests for checking diffusible hydrogen content in deposited metal.

The tests for checking the diffusible hydrogen content in the deposited metal shall be carried out in compliance with the provisions in **4.2.3** and **4.5.1.4** relevant to the flux-cored wire intended for welding the higher strength steels of categories: 1Y, 2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40, as well as 5Y and 5Y40.

Grade 2, 3 and 4 flux-cored wire intended for welding normal strength steels may be graded for the diffusible hydrogen content in the deposited metal as an option in accordance with the manufacturer's request.

The tests for checking the diffusible hydrogen content in the deposited metal are generally conducted at the initial approval of welding consumables, and also, if required by the Register, during annual tests or on the manufacturer's request during upgrading tests.

4.5.3 Welding wire and "wire - gas" combinations for automatic multi-run welding.

4.5.3.1 General requirements.

.1 the wire and "wire - gas" combinations tested according to **4.5.2** and approved by the Register for semiautomatic multi-run welding are also approved for automatic multi-run welding without additional testing. This provision is valid if the automatic and semiautomatic welding conditions (current, heat input, etc.) are similar, i.e. different in the way of welding torch movement only;

.2 the tests on the approval of an automatic multi-run welding technique shall be conducted according to **4.4.2** using a flux-cored wire or "wire - gas" combinations for welding test assemblies. The number of specimens required for testing and taken from each tests assembly shall be according to Table 4.4.1.4.

4.5.3.2 Deposited metal test.

4.5.3.2.1 Preparation and manufacture of test assemblies.

One test assembly of the deposited metal shall be welded in a downhand position as shown in Fig. 4.4.2.2.1.

The wire diameter, test assembly welding conditions (amperage, voltage, welding speed) shall comply with the manufacturer's recommendations.

The test assembly shall be prepared and manufactured according to **4.4.2.2.1**, except the requirements for the minimum thickness of each layer which shall be 3 mm.

4.5.3.2.2 Chemical analysis of deposited metal.

Test specimens shall be taken from a test assembly for chemical analysis of deposited metal, including the content of all alloying elements and impurities regulated by documentation for the product manufacturer and acceptance control (as a rule, for flux-cored wire).

4.5.3.2.3 Mechanical tests.

Two longitudinal tensile test specimens and three impact test specimens shall be taken from the test assembly as shown in Fig. 4.4.2.2.1. The specimens shall be cut out, prepared and tested according to **4.2.2.1.1** and **4.2.2.3**, respectively.

The results of all tests shall comply with the requirements of Table 4.4.2.2.4 for the corresponding welding consumables grades.

4.5.3.3 Butt weld tests.

4.5.3.3.1 Preparation and manufacture of test assemblies.

To check the properties of a butt welded joint in each welding position, one test assembly as shown in Fig. 4.4.2.3.1 shall be welded for which the "wire - gas" combination shall be approved. The welding positions to be approved are usually limited to the downhand position only, and in this case only one test assembly is required for testing. The wire diameter and welding conditions (amperage, voltage, welding speed) shall comply with the manufacturer's recommendations.

The test assembly shall be prepared and manufactured according to **4.4.2.3.1**.

4.5.3.3.2 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test assemblies is recommended for detecting any internal defects.

4.5.3.3.3 Mechanical tests.

As shown in Fig. 4.4.2.3.1 and in accordance with Table 4.4.1.4, from each butt weld test assembly the following specimens shall be taken:

two transverse flat tensile test specimens;

three transverse V-notched impact test specimens;

two transverse root and two transverse face bend test specimens.

The results of all tests shall comply with the requirements in Table 4.4.2.3.4 for the relevant welding consumable grades. The requirements for test procedure and their results evaluation shall meet the requirements in **4.2**.

4.5.3.4 Tests for checking diffusible hydrogen content in deposited metal.

The tests for checking the diffusible hydrogen content in the deposited metal shall be carried out in compliance with the provisions in 4.2.3 and 4.5.1.4 relevant to the flux-cored wire intended for welding the higher strength steels of categories: 1Y, 2Y, 2Y40, 3Y, 3Y40, 4Y, 4Y40, and also 5Y and 5Y40.

Grade 2, 3 and 4 flux-cored wire intended for welding normal strength steels may be graded for the diffusible hydrogen content in the deposited metal as an option in accordance with the manufacturer's request.

The tests for checking diffusible hydrogen content in the deposited metal are generally conducted at the initial approval of welding consumables, and also, if specified in the test program approved by the Register, during annual tests.

4.5.4 Welding wire and "wire - gas" combinations for automatic two-run welding.

4.5.4.1 General requirements.

The approval tests of the automatic two-run welding shall be conducted in compliance with **4.4.3** using a flux-cored wire or "wire - flux" combinations for welding test assemblies. The required number of test assemblies and specimens taken from each assembly for testing shall be according to Table 4.4.1.4.

4.5.4.2 Butt weld tests.

4.5.4.2.1 Preparation and manufacture of test assemblies.

The test assemblies shall be prepared and manufactured considering the following requirements:

.1 to approve the "wire - gas" combinations for the automatic two-run welding, two butt weld test assemblies prepared and manufactured according to **4.4.3.1** and **4.4.3.2** shall be welded within the base metal thickness range of 12 to 15 mm, and 20 to 25 mm. Where approval is requested for welding plates over 25 mm thick, then two test assemblies shall be prepared, one of the metal of about 20 mm thick, and another of the metal of the maximum thickness to be approved;

.2 edge preparation on the butt weld test assemblies is shown in Fig. 4.5.4.2.1. Some minor deviations in edge preparation are allowed if recommended by the manufacturer. For the test assemblies of a metal over 25 mm thick, the edge preparation details shall additionally be submitted for information. The deviations or differences in edge preparation shall be justified by the manufacturer's recommendations as applied to the given welding technique and metal thickness;

.3 diameters of the welding wire used for welding the test assemblies shall comply with the manufacturer's recommendations and be additionally submitted to the Register for information.

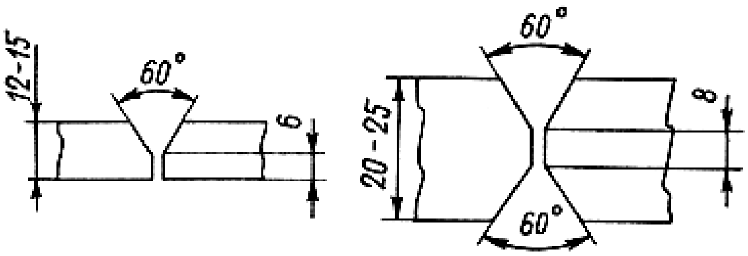


Fig. 4.5.4.2.1 Edge preparation recommended for butt weld test assemblies to approve "wire - gas" combinations for two-run welding

4.5.4.2.2 Radiographic testing.

Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test assemblies is recommended for detecting any internal defects.

4.5.4.2.3 Mechanical tests.

As shown in Fig. 4.4.3.2.1 and in accordance with Table 4.4.1.4, the test specimens, which type and number depend on the assembly thickness, shall be taken from each butt weld test assembly. The notch orientation and position on the specimens for impact testing shall be as shown in Fig. 4.4.3.2.3.

The results of all tests shall meet the requirements in Table 4.4.2.2.4 for longitudinal cylindrical tensile specimens and in Table 4.4.2.3.4 for the other types of specimens in accordance with the grade of the welding consumables to be approved.

The requirements for test procedure and their results evaluation shall meet the requirements in **4.2**.

4.5.4.3 Chemical analysis of deposited metal.

Test specimens shall be taken from a test assembly for chemical analysis of the deposited metal on the side of the second run, and the results shall be recorded in a test report, if the chemical composition is regulated by the manufacturer's documentation (as a rule for flux-cored wire).

4.5.4.4 Tests for checking diffusible hydrogen content in deposited metal.

The tests for checking diffusible hydrogen content in the deposited metal shall be carried out according to **4.5.3.4**.

4.5.5 Annual and upgrading tests.

4.5.5.1 Annual tests and re-approval surveys of the welding consumables manufacturers.

All the organizations recognized by the Register as welding consumable manufacturers to be used in "wire - flux" combinations shall be annually surveyed and their products shall be tested.

The annual tests shall, as a minimum, include the following:

.1 wires and combinations for semiautomatic multi-run or simultaneously for semiautomatic and automatic multi-run welding.

The extent of the annual tests for the wire and "wire - flux" combinations for the semiautomatic multi-run or simultaneously for semiautomatic and automatic multi-run welding shall include the preparation and tests of one deposited metal test assembly according to 4.5.2.2. The wire diameter shall correspond to the range of diameters specified in the Certificate for Approval of Welding Consumables for the semiautomatic welding. One longitudinal cylindrical tensile test specimen and three impact test specimens shall be tested, and the test results shall meet the requirements in Table 4.3.2.4.

The chemical analysis of the deposited metal shall be performed following the requirements for the initial approval if it is regulated by the manufacturer's documentation for the acceptance control of products (as a rule for flux-cored wire);

.2 wires and combinations for automatic multi-run welding.

The extent of the annual tests for the wire and "wire - flux" combinations for the automatic multi-run welding technique shall include the preparation and tests of one deposited metal test assembly according to 4.5.3.2. The wire diameter shall correspond to the range of diameters specified in the Certificate for Approval of Welding Consumables for the automatic welding. One longitudinal cylindrical tensile test specimen and three impact test specimens shall be tested, and the test results shall meet the requirements in Table 4.4.2.2.4.

The chemical analysis of the deposited metal shall be performed following the requirements for the initial approval if it is regulated by the manufacturer's documentation for the acceptance control of products (as a rule for flux-cored wire);

.3 wires and combinations for automatic two-run welding.

The extent of the annual tests for the wire and "wire - flux" combinations for the automatic two-run welding technique shall include the preparation and tests of one butt weld test assembly of 20 to 25 mm thick according to **4.5.4.2**. Where approval is requested for the automatic two-run welding, one transverse tensile test specimen, two bend test specimens, three impact test specimens, and also one longitudinal tensile test specimen shall be tested. The wire diameter used in welding shall be recorded in the test report;

.4 for H10 and H5 flux-cored welding wires with the controlled diffusible hydrogen content, the check of welding consumables for the diffusible hydrogen content in the deposited metal according to **4.2.3** may be included in the annual test program on the Register's demand.

4.5.5.2 Upgrading tests.

During upgrading tests of the welding consumables the following shall be taken into account:

.1 where the upgrading deals only with the change of temperature when testing impact test specimens for the multi-run welding technique, the test extent is similar to the requirements in **4.3.8.2.2**, and for the two-run welding technique, an additional (to the requirements in **4.5.5.1.3**) butt weld test assembly 12 - 15 mm thick shall be prepared for testing three impact test specimens;

.2 where the upgrading deals with the extension of the range of approval to cover the welding of higher strength level steels, then for the multi-run welding technique, the butt weld test assemblies shall be tested to the full extent according to **4.5.2.3** or **4.5.3.3** in addition to the usual extent of annual testing. The total extent of tests (annual and additional for upgrading) for the two-run technique shall meet the requirements for the initial approval according to **4.5.4**.

4.6 WELDING CONSUMABLES FOR USE IN ELECTROSLAG AND ELECTROGAS VERTICAL WELDING

4.6.1 General.

4.6.1.1 The requirements given below apply to the welding consumables intended for electroslag and electrogas vertical welding with forced weld forming with or without a consumable nozzle of hull structural steels, steel forgings and castings of the corresponding grades and of comparable steels intended for other structural applications.

The requirements on approval of welding consumables for the two-run welding according tor **4.4.3** also apply for approval of the above-mentioned welding consumables, except the particulars listed in **4.6.2** which primarily deal with the number and type of specimens for mechanical tests and are taken from butt weld test assemblies.

4.6.1.2 The welding consumables for electroslag and electrogas welding depending on the weld metal strength level (R_{eH}, min) are divided into the following grades:

1, 2, 3 and 4 for normal strength steels;

1Y, 2Y, 3Yand 4Y for higher strength steels with the specified yield stress of up to 355 MPa, inclusive;

2Y40, 3Y40, 4Y40 and 5Y40 for higher strength steels with the specified yield stress of up to 390 MPa, inclusive.

The approval of welding consumables for grades 1Y, 2Y, 3Y,4Y, 2Y40, 3Y40, 4Y40 and 5Y40 may be restricted for their use only with the special types of higher strength steel which allow welding at the high values of heat input. Generally, such steels shall be tested in accordance with **2.2.3**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships, and shall have a relevant record in the grade designation (-W…).

In this connection, the steels (usually niobium treated) corresponding in heat input to the technological process concerned shall be used in the approval testing. In so doing, one should take into account that the above listed requirements for dividing into grades may, due to technical reasons, have limited application for the welding consumables in question.

4.6.1.3 Where welding consumables shall be approved for welding normal and higher strength steels simultaneously, two test assemblies of higher strength steel shall be welded and tested. Two additional assemblies of normal strength steel may also be tested.

4.6.1.4 Information and documentation to be submitted for review.

A manufacturer shall submit for review the following information and technical documentation attached to the request for approval:

commercial name, type of welding wire, limits of chemical composition for bare wires or type of additives in the case of flux-cored wires (or reference to the relevant normative document), range of wire diameters to be approved;

producer, supplier, conditions of supply (surface condition, type, diameter and weight of the standard coils);
welding technique and combination grade, under which the approval is requested;
properties, composition and requirements relevant to the shielding gas or gas mixture;
commercial brand and manufacturer in the case of gas mixtures of special types;
type of flux and other consumables if used;
type of current and range of current, for which the approval is requested;
main characteristics of the welding equipment;
typical chemical composition of the deposited metal;
main operating characteristics and welding techniques, associated recommendations and limitations in general and in particular as regards edge preparation and welding parameters;
manufacturer's workshop, manufacturing facilities, manufacturing and treatment cycles, methods and procedures of manufacturer's quality controls;
packaging and marking;
recommendations for storing and preservation of wires and fluxes;
information on approvals granted by other classification societies or technical supervisory bodies including copies of the required documents.
The technical documentation to be approved by the Register includes:
manufacturer's technical specifications or specifications for welding consumables, including its topical editions of catalogues;
instructions on manufacture, acceptance and quality control.
4.6.2 Butt weld tests.
4.6.2.1 Preparation and manufacture of test assemblies.
Two butt weld test assemblies, one of 20 to 25 mm thick and another of 35 to 40 mm thick or more (refer to Fig. 4.6.2.3-1), shall be tested to approve the welding consumables for electroslag and electrogas welding.
The steel grade for preparing each of those test assemblies shall be selected in accordance with the instructions in Table 4.4.3.2.1 for two-run welding technique.
The chemical composition of the base metal for preparing the test assemblies, including the content of modifying (grain refining) elements, shall be given in a test report.
4.6.2.2 Radiographic testing.
Prior to the preparation of specimens for mechanical testing, the radiographic testing of butt weld test assemblies is recommended for detecting any internal defects.
4.6.2.3 Mechanical tests.
As shown in Fig. 4.6.2.3-1, the test specimens shall be taken for testing from each butt weld test assembly. The length of the test assembly shall be sufficient for sampling and preparing the following test specimens:
two longitudinal cylindrical tensile test specimens (2 *LT*);
two transverse flat tensile test specimens (2 *TT*);
two transverse side bend test specimens (2 *TB*);
two sets of three V-notch impact test specimens with the notch located as shown in Fig. 4.6.2.3-2:
one set with the notch located in the centre of the weld ($3KV_{CL}$);
one set with the notch located at 2 mm from the fusion line in the weld metal ($3KV+_{2FL}$);
one transverse macrosection (1*M*).
The results of all the tests shall meet the requi-rements in Table 4.4.2.2.4 for longitudinal cylindrical tensile test specimens and in Table 4.4.2.3.4 for the other types of test specimens according to the grade of the welding consumables to be approved.
The requirements for test procedure and their results evaluation shall meet the requirements in **4.2**.

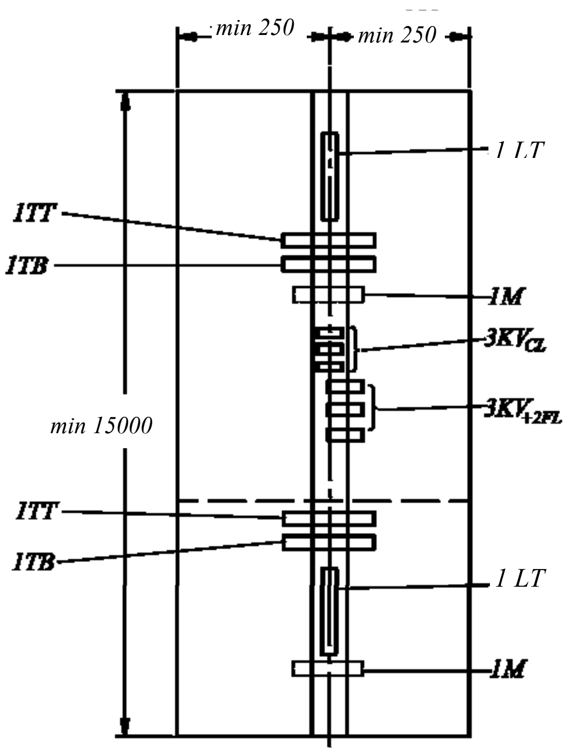


Рис. 4.6.2.3 – 1 Butt weld test assembly for testing to approve electroslag and electrogas welding. Test specimens are designated according to **4.6.2.3** (All dimensions are in mm)

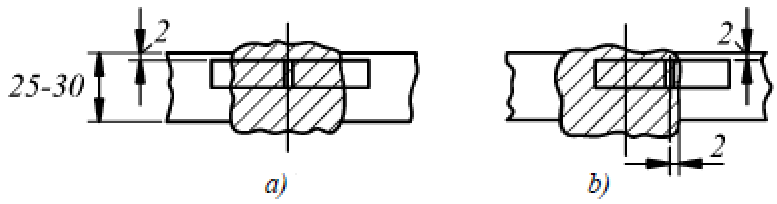


Fig. 4.6.2.3-2 Sketch for cutting-out and notch location for impact test specimens from the butt weld test assembly during test to approve electroslag and electrogas welding: *a* - with the notch located in the centre of the weld (KV_{CL}); *b* - with the notch located in the weld at 2 mm from the fusion line ($KV+_{2FL}$)

4.6.2.4 Chemical analysis of deposited metal.

Test specimens shall be taken from each test assembly for chemical analysis of the deposited metal, and the results shall be presented in a test report, if the chemical composition is regulated by the manufacturer's documentation.

4.6.3 Annual and upgrading tests.

4.6.3.1 Annual tests and re-approval surveys of the welding consumables manufacturers.

All the organizations recognized by the Register as welding consumables manufacturers for electroslag and electrogas welding shall annually be surveyed and their products be tested.

The annual tests shall include welding and testing of one butt weld test assembly of 20 to 25 mm thick according to **4.6.2**.

The annual tests shall include welding and testing of the following types of specimens:

one longitudinal cylindrical tensile test specimen;

one transverse flat tensile test specimen;

two transverse side bend test specimens;

three V-notch impact tests specimens with the notch located in the centre of the weld (as shown in Fig. 4.6.2.3-2a);

three V-notch impact tests specimens with the notch located in the weld at 2 mm from the fusion line (as shown in Fig. 4.6.2.3-2b));

one transverse macrosection (1M).

The results of all the tests shall meet the requirements in Table 4.4.2.2.4 for longitudinal cylindrical tensile test specimens and in Table 4.4.2.3.4 for the other types of test specimens according to the grade of the welding consumables to be approved.

4.6.3.2 Upgrading tests.

Upgrading tests shall be conducted only on the basis of a manufacturer's request and preferred to be combined with the annual tests.

As a rule, all the tests of butt weld test assemblies required to approve electroslag and electrogas welding according to **4.6.2** shall be carried out in upgrading the welding consumables. In this case the test results obtained for the specific welding consumables when they were used in the approval of other welding techniques shall be ignored.

4.7 WELDING CONSUMABLES FOR WELDING HIGH STRENGTH STEEL

4.7.1 General.

4.7.1.1 For welding consumables the requirements of this Chapter supplement those in **4.3**, **4.4** and **4.5** and specify the conditions for approval and testing of the welding consumables intended for welding high strength steels delivered in heat treated condition (quenched and tempered) or after the TMCP, and meeting the requirements in **3.13**, Part XIII "Materials".

When the special requirements are lacking, the similar requirements for approval of the welding consumables for welding normal and higher strength hull structural steels shall apply.

4.7.1.2 The requirements of this Section are used for approval of the following types of welding consumables:

covered electrodes for manual arc welding (similar to **4.3**);

"wire - flux" combinations for multi-run submerged arc welding (similar to **4.4.2**);

"wire - gas" combinations for gas-shielded metal-arc welding (including tungsten inert gas welding - TIG);

flux-cored wire with or without shielding gas for metal-arc welding.

4.7.1.3 The welding consumables for welding the high strength steels, complying with the requirements in **3.13**, Part XIII "Materials", are divided into grades depending on the minimum yield stress of the base and deposited metals, as well as the temperature in impact testing the weld and deposited metal according to Table 4.1.2.3.

The designation of the welding consumable grade includes two groups of basic symbols:

3, 4 and 5 for designating the temperature during testing the impact test specimens for the deposited and weld metals;

Y42, Y46, Y50, Y55, Y62, Y69, Y89 and Y96 for designating the requirements for the minimum yield stress of the deposited metal.

For the welding consumables intended for welding high strength steels, the following additional symbols according to 4.1.2.6 are used:

H10 and H5 - for content of diffusible hydrogen in the deposited metal according to 4.2.3.4;

S - for approval of welding consumables for semiautomatic welding;

M - for approval of welding consumables for multi-run welding technique;

SM - for approval of welding consumables for semiautomatic and automatic multi-run welding technique.

4.7.1.4 The welding consumable grade shall be used and selected considering the grade the high strength steel to be welded and requirements in **2.2.5**.

4.7.2 Deposited metal test.

4.7.2.1 Depending on the type of welding consumables and the degree of the welding procedure mechanization, the test assemblies of the deposited metal shall be welded in a downhand position following the relevant provisions in **4.3.2.1**, **4.4.2.2.1** or **4.5.3.2.1**. The high strength steel compatible in properties (refer to **4.7.1.4**) with the weld metal shall be used as the base metal for preparing the test assemblies. As an alternative, the bevels of the test assembly of any grade metal shall be buttered with the welding consumables to be approved or with those similar in composition and properties.

4.7.2.2 Following the requirements in **4.3.2.2**, **4.4.2.2.2**, **4.5.2.2.2** or **4.5.3.2.2**, the test assemblies shall be sampled for chemical analysis of the deposited metal including the content of all alloying elements and impurities if these regulated by documentation for the product manufacture and acceptance control. The analysis results shall be within the limits set by the standards or manufacturer's documentation.

4.7.2.3 Depending on the type of welding consumables and the degree of the welding procedure mechanization, test specimens shall be taken from the deposited metal test assemblies and prepared for the tests, which the type and number shall comply with the relevant requirements in **4.3.2.3, 4.4.2.2.3, 4.5.2.2.3** or **4.5.3.2.3**.

4.7.2.4 The mechanical properties shall meet the requirements in Table 4.7.2.4.

The requirements for test procedure and results evaluation shall comply with the provisions in **4.2**.

4.7.3 Butt weld tests.

4.7.3.1 Depending on the type of welding consumables and the degree of the welding procedure mechanization, the butt weld test assemblies according to the relevant provisions in **4.3.3.1**, **4.3.3.2**, **4.4.2.3.1**, **4.5.2.3.1** or **4.5.3.3.1** shall be prepared and welded. For welding consumables the high strength steel with the proper values of the minimum yield stress and tensile strength and compatible in impact toughness indices with the welding consumables to be approved shall be used as the base metal for preparing the test assemblies (refer to **2.2.5**).

4.7.3.2 Depending on the type of welding consumables and the degree of the welding procedure mechanization, test specimens shall be taken from the butt weld test assemblies and prepared for the tests, which the type and number shall comply with the relevant requirements in **4.3.3.3, 4.4.2.3.3, 4.5.2.3.3** or **4.5.3.3.3**. Prior to the preparation of test specimens, the radiographic testing of the butt weld test assemblies is recommended for checking the presence of any internal defects.

4.7.3.3 The mechanical properties shall meet the requirements in Table 4.7.3.3.

The requirements for test procedure and results evaluation shall comply with the provisions in **4.2**.

4.7.3.4 Where the bend angle required in Table 4.7.3.3 is not achieved until the first crack, the specimen may be considered as satisfactory tested (meets the specified requirements) if the elongation measured on the gauge length L_0 of the bend test specimen meets the requirements in Table 4.7.2.4 for the minimum elongation value for cylindrical tensile test specimens. The gauge length is determined from the relationship $L_0 = L_S + t$,

where: L_S – the weld width, t – the specimen thickness (refer to Fig. 4.7.3.4).

Table 4.7.2.4

Grade		Yield stress R_{eH}, MPa, min	Tensile strength R_m, MPa [1, 2]	Elongation min A_5 ($L_0 = 5d$), %, min	Impact test	
					Test temperature, °C	Impact energy KV, J, min
3	Y42	420	530 ÷ 580	20	-20	47
4					-40	
5					-60	
3	Y46	460	570 ÷ 720	20	-20	47
4					-40	
5					-60	
3	Y50	500	610 ÷ 770	18	-20	50
4					-40	
5					-60	
3	Y55	550	670 ÷ 770	18	-20	55
4					-40	
5					-60	
3	Y62	620	720 ÷ 890	18	-20	62
4					-40	
5					-60	
3	Y69	690	770 ÷ 940	17	-20	69
4					-40	
5					-60	
3	Y89	890	940 ÷ 1100	14	-20	69
4					-40	
3	Y96	960	980 ÷ 1150	13	-20	69
4					-40	

[1] The ultimate tensile strength for the deposited metal can be 10% lower than the values specified in the Table, provided that the requirement of Table 4.7.3.3 is met for the value of ultimate tensile strength when testing transverse flat tensile test specimen from a butt weld sample.

[2] For welding products of very large thicknesses (50 mm and over), when the strengthening effect of the base metal in accordance with note "1" does not work, and the tensile strength of the deposited metal determines the tensile strength of the welded joint, welding consumables of the following strength category (with a higher value index "Y" in the category designation) shall be used.

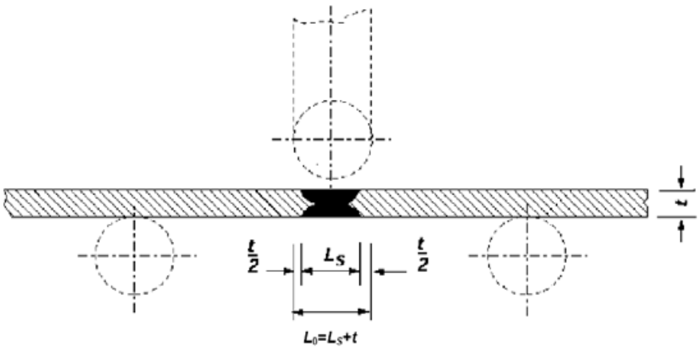


Fig. 4.7.3.4 Sketch for determination of the gauge length L_0 0 to determine elongation value during bend tests

Table 4.7.3.3

Grade		Tensile strength R_m, MPa, min	Bend test		Impact test	
			Bend angle, deg[2]	Ratio D/t [1]	Test temperature, °C	Impact energy KV, J, min
3	Y42	530	120	4	-20	47
4					-40	
5					-60	
3	Y46	570		4	-20	47
4					-40	
5					-60	
3	Y50	610		4	-20	50
4					-40	
5					-60	
3	Y55	670		5	-20	55
4					-40	
5					-60	
3	Y62	720		5	-20	62
4					-40	
5					-60	
3	Y69	770		5	-20	69
4					-40	
5					-60	
3	Y89	940		6	-20	69
4					-40	
3	Y96	980		7	-20	69
4					-40	

[1] D – mandrel diameter, t – specimen thickness

[2] The bend angle achieved before the origination of the first crack. Minor weld defects less than 3 mm long revealed on the specimen surface are acceptable.

4.7.4 Tests for checking diffusible hydrogen content in the deposited metal.

4.7.4.1 The all grades welding consumables for welding high strength steels, except "solid wire _ gas" combinations, shall be subjected to tests for checking diffusible hydrogen content in the deposited metal using the following methods:

vacuum-mercury method complying with the requirements of ДСТУ EN ISO 3690 or the applicable ISO or EN standard;

vacuum method complying with the requirements in ДСТУ EN ISO 3690 or the applicable ISO or EN standard (method 2);

chromatographical method complying with the requirements in ДСТУ EN ISO 3690 or the applicable ISO or EN standard (method 1) or the Register-agreed procedure. In the latter case the cooling rate and the time for specimens preparation, and also the diffusible hydrogen amount to be determined shall be comparable with those specified in the reference method according to ДСТУ EN ISO 3690 or the applicable ISO or EN standard.

4.7.4.2 The diffusible hydrogen content in the deposited metal checked according to **4.2.3** shall not exceed the limits in Table 4.7.4.2.

Table 4.7.4.2

Grade by yield stress value	Classification symbols by diffusible hydrogen content	Maximum hydrogen content, cm^3 per 100 g of deposited metal
Y42 Y46 Y50	H10	10
Y55 Y62 Y69 Y89 Y96	H5	5

4.7.5 Annual tests.

All the organizations recognized by the Register as welding consumables manufacturers shall be annually surveyed and their products be tested. Depending on the type of welding consumables and the degree of the welding procedure mechanization, the annual test extent includes welding the deposited metal test assemblies and carrying out the tests according to the relevant provisions in **4.3.8.1.1**, **4.4.4.1.1**, **4.5.5.1.1** or **4.5.5.1.2** with due regard to additional requirements in **4.7.2**.

For welding consumables of grades Y69 and Y96, annual test of materials for diffusible hydrogen content in the deposited metal shall be included into the test program in accordance with **4.2.3**.

4.8 WELDING CONSUMABLES FOR WELDING OF CORROSION-RESISTANT (STAINLESS) STEEL AND FOR SURFACING

4.8.1 General.

4.8.1.1 The present requirements apply to welding consumables intended for welding of corrosionresistant (stainless) steels meting the requirements of **3.16**, Part XIII "Materials", also for metal deposition to ship machinery items.

This Chapter contains provisions related to approval and testing of welding consumables.

When preparing the test assemblies and conducting individual types of tests, one shall be guided by respective provisions of **4.2**.

4.8.1.2 The welding consumables for welding of corrosion-resistant steels are divided into grades depending on the structure and composition of steels to be welded in accordance with directions of Table 4.8.1.2. It is assumed that the weld metal has the alloying system similar to that of the base metal and provides mechanical properties and corrosion resistance identical to those of the base metal.

In cases, when the welding consumables are employed for deposition or for welding dissimilar joins, the classification presented in Table 4.8.1.2 is retained, but serving as the basis for it is the chemical composition and structure of the deposit or weld metal (and not of assembled or deposited parts).

4.8.1.3 Designation of the grade of welding consumables intended for welding of corrosion-resistant steels and for deposition shall include, additionally, identification (in brackets) of typical (brand) chemical composition of deposited metal, as specified in **3.16.1.1**, Part XIII "Materials" for steels.

Example: A-6 (x5CrNiMo 19 11 3), where,

A-6 is a grade of welding consumable according to classification given in Table 4.8.1.2;

x5 is carbon fraction of total mass, in %;

Cr, Ni, Mo are symbols of respective alloying elements (chrome, nickel, molybdenum);

19, 11, 3 are fractions of total mass of the above alloying elements (Cr, Ni and Mo, respectively).

4.8.1.4 The requirements of this Chapter apply to the following welding consumables and welding processes:

coated electrodes for manual arc welding;

combinations "wire - flux" for automatic and semi-automatic welding;

combinations "strip - flux" for automatic deposition;

combinations "wire - gas" for semi-automatic and automatic active and inert-gas metal-arc active or inert-gas welding;

combinations "wire - gas" for automatic tungsten inert-gas arc welding;

combinations "rod - gas" for manual tungsten inert-gas welding;

combinations "wire - gas" for automatic inert-gas plasma-arc welding;

flux cored wire for automatic and semi-automatic metal arc welding with or without gas shield.

4.8.1.5 The requirements for welding consumables' approval procedure and also for survey of manufacturers and procedure of issuing the Certificates of Approval of Welding Consumables shall comply with the directions of **4.1**.

Table 4.8.1.2

Grade of welding consumable	Welded steel			Scope of application [1]	
	Designation of typical composition	Brands		AISI/UNS	National
		AISI/UNS	National		
1	2	3	4	5	6
M-1	x20Cr13 x30Cr13	410 420	20X13 30X13	410 420	20X13, 30X13
	x7CrNiNb 16 4	–	07X16H4Б, 07X16H4	–	07X16H4Б, 07X16H4
MF-2	x15CrNi 17 2	431	14X17H2	431	I4XI7H2
	x l0CrNi 13 1	414, 41 S	08X14НДЛ, 05X12H2T	414, 410S	08X14НДЛ, 05X12H2T
	xl0CrNi 15 4	429	08X15H4ДМЛ	429	08X15H4ДМЛ
F-3	x8CrTi 17	430 T	08X17T	430T	08X17T
AM-4	x8CrNiTi 17 6	–	08X17H6T	–	08X17H6T
A-5	x3CrNi 19 11	304L	03X18H11, 03X18H12	304L	03X18H11,03X18H12
	x3CrNiN 19 11	304LN	-	304L, 304LN	Таж
	x8CrNiTi 18 11	321	08X18H10T	321, 347, 304L, 304LN	Таж + 08X18H10T, 08X18H12Б
	x8CrNiNb 18 11	347	08X18H12Б	321, 347, 304L, 304LN	Таж + 08X18H10T, 08X18H12Б
A-6	x3CrNiMo 19 11 3	316L	03X 7H14M3	304L, 3I6L	03XI8H11, 03XI8H12, 03XI7H14M3
	x3CrNiMo 19 13 4	317L	–	304L, 3I6L, 316LN, 3I7L	Таж
	x3CrNiMoN 19 11 3	316LN	-	321, 347, 304LN, 304L,316LN, 317L, 3I6Ti, 316Nb	Таж + 08X18H10T, 08X18H12Б
	x3CrNiMoN 19 13 4	317LN	-	321, 347, 304LN, 304L, 316LN, 317L, 317LN, 3I6Ti,316Nb	Таж + 08X18H10T, 08X18H12Б
A-7ss	x2CrNiMoCu 21 25 5 2	N08904(904L)	–	N08904(904L)	–
	x2CrNiMoCuN 20 18 6 1	S 31254	–	S31254	-
AF-8dup	x3CrNiMoN 22 5 3	S31803	03X22H6M2, 08X22H6M2	S31803	08X22H6M2
	x3CrNiMoWCuN 25 7 3	S 1260	08X21H6M2T	S31260, S31803	08X22H6M2, 08X21H6M2T
	x4CrNiMoCuN 26 6 4 2	S32550	–	S32550, S32760	-
	x3 CrNiMoN 6 8 5	S32750	–	S32550, S32750, S32760	–
	x3 CrNiMoWCuN 26 8 4 1 1	S32760	-	S32550, S32760	-

A-9sp (special)	x8CrNi 24 14	309	–	309, 309L, 309Mo, 309S, 309SCb:	-
	Dissimilar joints, e.g. D40+A-6, etc. Weld metal composition: x2CrNi 24 12; x10CrNi 24 12; x8CrNiMo 23 13; x10CrNiMo 24 13 2 and the like			Dissimilar welded joints. Intermediate (transition) layers for stainless liners including intermediate runs of clad steel joints;	
A-10sp (special)	Dissimilak joints, e.g. E500 + AF-8 etc. Weld metal composition: x9CrNiMoMnN 16 25 6 2 x9CrNiMoMnVN 16 25 6 2 1			Dissimilar welded joints. Intermediate (transition) layers for stainless liners including intermediate runs of clad steel joints. Welding of grade M-1, MF-2, F-3 and AM-5 steels, as well as limited weldability steels without heating.	
	x1CrNi 26 22, x10CrNi 26 22			Ditto + welding of type 310 and 310Mo steels	

[1] The scope of application is valid under the condition of meeting the requirements for the mechanical properties of the deposited metal and welded joint according to Tables 4.8.4.1-1 and 4.8.4.1-2.

4.8.2 Scope and types of tests for welding consumables.

4.8.2.1 Welding consumables for welding of corrosion-resistance steels.

As a rule, the welding consumables intended for welded joints on corrosion-resistant steels shall be subjected to the following tests:

for determination of deposited metal properties;

for determination of butt-welded joint properties;

testing of weld metal for resistance to intercrystalline corrosion (ICC);

testing for resistance to hot cracking.

For respective grades of welding consumables, as required in accordance with the range of approval requested by the manufacturer, additional corrosion tests are conducted. For example:

determination of resistance to pitting corrosion initiated by chlorides (sea water);

testing on stress-corrosion cracking in environments containing hydrogen sulphide at room and higher temperatures, etc.

Actual scope of tests for different grades of welding consumables intended for welding of corrosionresistant steels shall be defined in accordance with the requirements of Table 4.8.2.1.

Table 4.8.2.1. **Scope and types of tests of welding consumables for corrosion-resistant steels**

Types of test assembly and characteristics to be determined	Grades of welding consumables									
	M-1	MF-2	F-3	AM-4	A-5	A-6	A-7	AF-8	A-9sp	A-10sp
Test assembly of deposited metal:										
R_m	+	+	+	+	+	+	+	+	+	+
$R_{p0,2}$	+	+	+	+	+	+	+	+	+	+
$R_{p1,0}$	–	–	–	–	–	+	–	–	–	–
A_5	+	+	+	+	+	+	+	+	+	+
$KV^{+20°}$	+	+	+	+	+	+	+	+	+	+
KV below zero	–	–	–	–	–	+	–	–	–	–
chemical composition of deposited metal	+	+	+	+	+	+	+	+	+	+
Test assembly of butt weld:										
R_m^{cond} with recording of specimen failure point location	+	+	+	+	+	+	+	+	+	+
angle of V-bend in static bending test	+	+	+	+	+	+	+	+	+	+
weld metal resistance to ICC (intercrystalline corrosion)	+[3]	–	+	+	+	+	+	+	+[3]	+[3]
weld metal resistance to pitting corrosion	–	–	–	–	–	–	+	+	–	–
weld metal resistance to stress corrosion in presence of hydrogen sulphide	–	–	–	–	–	–	+	+	–	–
α- phase content in weld metal	–	–	–	–	–	+	–	+	+	–
Technological test assembly for determination of tendency to hot cracking [1]	+	+	+	+	+	+	+	+	+	+
Multilayer deposition [2]:										
α- phase content	–	–	–	–	–	+	–	+	+	–
chemical check analysis	+	+	+	+	+	+	+	+	+	+
resistance of deposited metal to ICC	+[3]	–	+	+	+	+	+	+	+[3]	+[3]

[1] By agreement with the Register the tee-joint test assembly may be replaced by layer-by-layer control of other types of test assemblies.
[2] The multi-layer deposition is performed in accordance with a separate Register requirement, for example, when it is necessary to carry out a check analysis of α -phase content using the volumetric magnetic method.
[3] Tests for resistance to ICC are conducted only for welding consumables, the composition which, as guaranteed by the manufacturer, ensures the required properties, for example, M-1 (X7CrNiNb 164), A-9sp (X2CrNiNb 24 12), A-10sp (X1CrNi 26 22)

4.8.2.2 Welding consumables for deposition of corrosion-resistant cladding layers.

The welding consumables intended for deposition of corrosion-resistant cladding layers to ship machinery items, as a rule, shall be subjected to the following tests:

for determination of deposited metal properties;

for determination of technological strength of the cladding layer in static bending tests;

testing of cladding metal layer for resistance to intercrystalline corrosion;

testing for resistance to hot cracking.

Additional corrosion tests of the cladding layer are conducted in accordance with a separate requirement of the Register in compliance with the directions of **4.8.2.1**.

Actual scope of testing for welding consumables of different grades intended for deposition jobs shall be determined in accordance with the requirements of Table 4.8.2.2.

Table 4.8.2.2. **Scope and types of tests of welding consumables for deposition to ship machinery items**

Type of test assembly and characteristics to be determined	Grades of welding consumables					
	A-5	A-6	A-7	AF-8	A-9sp	A-10sp
Deposited metal test assembly [1]:						
R_m	+	+	+	+	+	+
$R_{p0,2}$	+	+	+	+	+	+
$R_{p1,0}$	+	+	–	–	–	–
A_5	+	+	+	+	+	+
$KV^{+20°}$	+	+	+	+	+	+
Chemical composition of deposited metal	+	+	+	+	+	+
Simulation test assembly of cladding deposit:						
static bending test	+	+	+	+	+[2]	+[2]
α- phase content	+	+	–	+	+	–
chemical check analysis	+	+	+	+	–	–
resistance of deposited metal to ICC	+	+	+	+	+[3]	+[3]
resistance of cladding metal to pitting corrosion	–	–	+	+	–	–
resistance of deposited metal to stress corrosion in presence of hydrogen sulphide	–	–	+	+	–	–
layer-by-layer checking for appearance of hot cracks	+	+	+	+	+	+

[1] For combinations "strip - flux" the specimens intended for determination of the above characteristics shall be taken from multilayer deposited metal.
[2] Tests shall be carried out using combinations with other consumables forming the clad layer.
[3] The test for resistance to ICC is mandatory, when the range of approval requested by the manufacturer includes both the transition and main layers of the deposited metal consisting of corrosion-resistant material of type A-9sp (X2CrNiNb 24 12), A-10sp (X1CrNi 26 22).

4.8.3 Requirements to preparation of test assemblies.

4.8.3.1 General.

The types of test assemblies and requirements to their manufacture, in accordance with directions of **4.2**, are also valid for welding consumables intended for welding of corrosion-resistant steels and deposition operations.

In addition to those the following specific features of application of high-alloy welding consumables shall be taken into account:

possibility of lower resistance to inter-crystalline corrosion in the heat-affected zone of the base metal, especially in welding with high heat input;

increased tendency of high-alloy weld metal to hot cracking in comparison with low-alloy welding consumables;

higher degree of weld metal contraction in comparison with low-alloy welding consumables and, as a result, considerable angular and linear strains in the process of welding;

higher yield of melted metal requiring limitation of the melted weld pool volume and use of smaller diameter welding wire in comparison with low-alloy materials in identical conditions of welding;

higher specific resistance and lower values of thermal conductivity of high-alloy welding consumables, which requires limitation of the current unit load.

4.8.3.2 Testing of deposited metal.

To test the deposited metal, the following test assemblies shall be prepared and welded in downhand position:

one test assembly, as shown in Fig. 4.3.2.1, intended for manual and semi-automatic welding;

one test assembly, as shown in Fig. 4.4.2.2.1, intended for automatic welding.

As the base metal for preparation of the test assemblies a steel shall be used, which corresponds to the grade of welding consumable indicated in Table 4.8.1.2. As an alternative for preparation of the test assemblies, hull structural steel of normal or higher strength of any grade may be used, with preliminary facing of weld edges with welding consumables to be certified or of similar grade. As shown in Fig. 4.8.3.2, three layers shall be deposited: the first one with consumables for padding of transition layers of Grade A-9sp or A-10sp, and then two cladding layers, using the welding method and consumables to be certified.

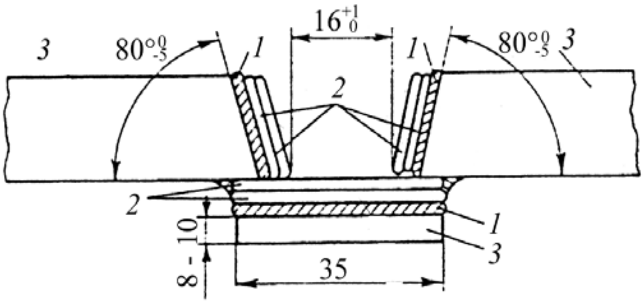


Fig. 4.8.3.2. Diagram of edge preparation by deposition for testing of deposited metal 1 - transition layer/backing (welding consumables of Grades A-9sp and A-10sp); 2 - main cladding layer (welding consumables to be certified); 3 - base metal (steel of normal or higher strength)

In this case the deposition by submerged arc (combination "wire - flux") may be replaced with deposition of the cladding layer using combination "wire - gas" or coated electrodes of similar grade and of similar chemical composition.

After deposition of metal layers to the edges of the weld it is recommended to dress the buttered edges with abrasive tools or to perform machining of the edges and the backing strip to restore the geometrical parameters of the prepared edges shape.

For welding of the assembly with deposited metal it is recommended, depending on the welding process and type employed to select the welding wire (or filler rods) with diameter corresponding to values indicated in Table 4.8.3.2. The welding conditions shall comply with directions of the welding consumables manufacturer and with the technical documentation for welding of structures approved by the Register.

Table 4.8.3.2

Welding type	Welding process (standard (ДСТУ ISO 4063 or ISO 4063)	Diameter of welding wire (rod), mm	
		for facing of edges	for filling of the groove
Manual	111	2,5 – 3,0	3,0 – 4,0
Automatic	12	2,0	2,5 – 3,2
Semi-automatic and automatic	131 135	1,0 – 1,2 1,0 – 1,2	1,4 – 1,6 1,4 – 1,6
Manual	141	2,0 – 2,4	2,5 – 3,2
Automatic	141	1,0 – 1,6	1,2 – 1,6
Semi-automatic and automatic	114 136 137	0,9 – 1,4 0,9 – 1,2 0,9 – 1,2	1,2 – 1,6 1,2 – 1,6 1,2 – 1,6
Manual	15	2,0 – 2,4	2,0 – 3,0
Automatic	15	1,0 – 1,2	1,2 – 1,6

Heat treatment after welding of deposited metal assemblies is not used normally. Exception is made for welding consumables employed for metal deposition on ship machinery articles. In this case the assemblies are subjected after welding to imitated single-time tempering of welded joint at 630 - 650°C during 40 min with subsequent cooling in the air. The temperature inside the furnace before loading of the specimens shall not exceed 350°C.

4.8.3.3 Butt weld tests. To determine the weld properties, it is necessary to carry out welding of assemblies, the quantity and dimensions of which are indicated in **4.2** for respective welding consumables and welding processes.

The quantity of test assemblies may be reduced within the following limits:

for welding consumables intended for downhand welding only one test assembly is sufficient;

for combinations "wire - gas" (131, 135, 141 and 15 by ДСТУ ISO 4063 or ISO 4063). two assemblies are required. In this case the properties of butt welds shall be determined with respect to downhand and vertical (vertical-upward) welding positions.

For welding of joint assemblies it is recommended to use welding wire with diameters, as specified in Table 4.8.3.2:

for root passes follow the directions given for facing of edges of deposited metal test assemblies;

for filling of the grooves follow the respective directions for deposited metal test assemblies.

The butt-welded test assemblies shall be prepared using the steel of the same grade, which is specified for the welding consumables. When selecting the base metal for a butt-welded test assembly, one shall take into account the necessity to ensure the level of the weld properties specified in Table 4.8.4.1-2 for the grade of welding consumables to be certified.

For welding consumables of Grades A-9sp and A-10sp intended for dissimilar joints and deposition of intermediate layers, the butt-welded test assemblies may be prepared in two ways:

one side of the test assembly is produced from corrosion-resistant steel of Grade A-5 or A-6, the other side from higher or high strength steel with ultimate breaking strength at least equal to that of deposited metal;

both sides of the test assembly are produced from higher or high strength steel with the level of strength corresponding to the welding consumable to be certified.

4.8.3.4 Hot cracking test.

The welding consumables intended for corrosion-resistant steels shall be subjected to hot cracking test estimated on test results of tee-joint test assemblies. In case of manual or semi-automatic welding for each welding consumable to be approved, three test assemblies shall be welded, their dimensions as shown in Fig. 4.2.4.1, in case of automatic welding - one test assembly of $L \geq 500$mm shown in Fig. 4.2.5.

The base metal for manufacture of test assemblies, as well as diameters of welding wire/rods, shall be selected as specified in **4.8.3.3**.

For welding consumables intended exclusively for deposition operations, manufacture of tee-joint test assemblies may be omitted. In this case the resistance to hot cracking is estimated with the use of layer-bylayer control method for the deposited metal and also in the process of side-bend testing of specimens with cladding deposit.

4.8.3.5 Static bending test for fusion-clad layers.

4.8.3.5.1 Bend testing of fusion-clad layers is performed for estimation of clad layer plastic properties, bond surface, as well as heat affected zone.

This type of testing may be done in the following ways:

bending with tensioning of the clad layer (the load is applied normally to the bond surface) and with strain orientation normally to the direction of welding in the process of deposition;

bending with tensioning of the clad layer (the load is applied parallel to the bond surface) and with strain orientation along the direction of welding in the process of deposition; side-bend testing of specimens (the load is applied parallel to the bond surface). In this case the bending load may either coincide with the direction of welding, or be perpendicular to it.

Testing of fusion-clad layer shall be performed by side-bend method with the load applied normally to the direction of welding. In static bending other types of tests employed, as required by the Register in cases of ambiguity of the main test results.

Note. The side-bend testing with load application parallel to the direction of welding is performed, as a rule, in approval of welding deposition procedures, as this is the most objective method for estimation of internal defects (poor fusion, cracks, etc.) caused directly by technological factors.

4.8.3.5.2 To conduct static bending test of fusion-clad layers, an assembly-imitator of the cladding deposit shall be manufactured, as required by 4.8.3.5.2. The cladding layer shall be deposited on hull structural steel of any grade of higher or high strength ensuring proper testing with a mandrel of required diameter (refer to Fig. 4.8.4.2).

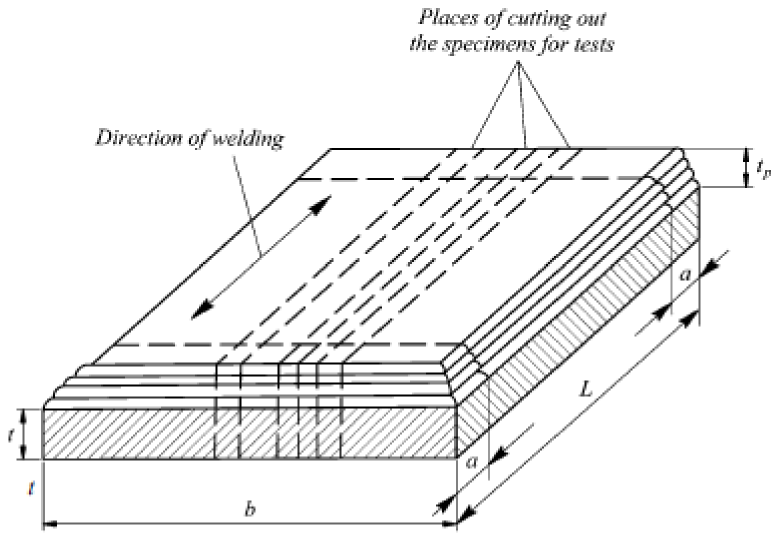


Fig. 4.8.3.5.2. Assembly imitating cladding deposit:
t - thickness of base metal; t_p - thickness of cladding layer after machining; b - width of assembly; L – length of assembly; a – waste;

Note. Requirements to dimensions, in mm:
a) for manual and semi-automatic deposition:
$t = 14 – 16$, $6 \le t_p \le 10$, $b \ge 60$, $L \ge 200$, $a \approx 25$;
b) for automatic submerged-arc deposition with welding wire:
$t = 16 – 20$, $6 \le t_p \le 10$, $b \ge 100$, $L \ge 480$, $a \approx 50$;
c) for automatic submerged-arc deposition with strip electrode:
$t = 16–20$, $6 \le t_p \le 10$, $b \ge 120$, $L \ge 480$, $a \approx 50$.

The deposition shall be performed with observation of the requirements and recommendations given below.

The first layer (sublayer) shall be deposited using welding consumables of group A-9sp. The thickness of the first layer shall be 3 to 4 mm. The corrosion-resistant deposit shall be made with welding consumables to be approved in 2 or 3 layers, with overlapping of the beads. The plan of deposition beads application shall keep deformation of the main plate to a minimum. The total thickness of the cladding layer after machining shall not exceed 10 mm.

The arrangements for static bending specimens cutting from the imitation test assembly are shown in Fig. 4.8.3.5.2.

If the range of approval for welding consumables permits heat treatment of fusion-clad items, the imitation assembly, before cutting the specimens out of it, shall be subjected to single-time tempering at 630–650 °C during 40 min with subsequent cooling in the air. To avoid distortion of the plate, the temperature in the furnace at loading of the test assembly into it shall not exceed 350°C. Depending on the range of approval requested by the manufacturer the following ways of heat treatment are possible:

after deposition of intermediate layer;

after deposition of intermediate layer and of all cladding layers; two-stage heat treatment:

after deposition of sublayer, then after deposition of all cladding corrosionresistant layers.

4.8.3.6 Test assemblies for preparation of specimens tested for resistance to intercrystalline corrosion.

In testing of welding consumables resistance to ICC may be estimated using specimens of weld metal or deposited metal. In such circumstances the testing of consumables employed exclusively for deposition jobs (for example, for compositions "strip-flux") may be limited to deposited metal only. In all other cases, unless otherwise agreed upon with the Register, used as the main method of testing for resistance to ICC shall be the method that involves testing of the weld metal in accordance with directions of **4.8.3.6.1**.

4.8.3.6.1 Butt joint test assembly for testing of weld metal resistance to ICC.

Testing for resistance of weld metal to ICC shall be carried out by welding of test assemblies having dimensions as shown in Fig. 4.8.3.6.1.

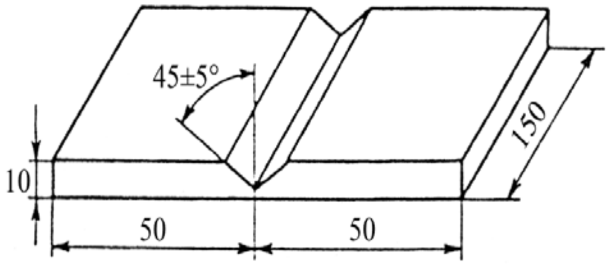


Fig.4.8.3.6.1.
Проба Welded joint test assembly for cutting out specimens to be tested for resistance to ICC
(dimensions in mm, unless otherwise indicated)

In automatic and mechanized welding types the beginning and the end of the weld shall be executed on extended backing strips with dimensions ensuring steady welding procedure and absence of inadmissible defects on the controlled length of the test assembly (but not less than 100x100x10 mm).

The backing strip edge preparation shall have a depth of not less than 6 mm and groove angle similar to that of the test assembly (90°).

Used as the base metal shall be a corrosion-resistant steel complying in its grade and chemical composition with the filler material to be approved.

The following limitations shall be observed in the process:

the corrosion-resistant steel shall be also resistant to ICC, even after provoking heating;

the base metal shall provide satisfactory results in bend-over tests when using a mandrel of the required diameter;

the mechanical properties of the base metal shall ensure uniform distribution of the residual plastic strain over the weld and near-weld area when testing static bending specimens.

To fully meet the above requirements to the base metal, it is permitted to use plates of corrosionresistant steels differing in grade from the filler material under condition that plate edges are buttered previously with tested filler materials (or materials similar in chemical composition).

The Register may require heat treatment after welding, if this appears necessary for the range of approval requested by the manufacturer of the materials.

4.8.3.6.2 Test assembly for deposited metal testing for resistance to ICC.

The checking of deposited metal in the cladding layer for resistance to ICC shall be conducted on the checking test assemblies prepared with the use of welding consumables to be certified. General requirements for welding of the test assemblies are similar to those indicated in **4.8.3.2** and **4.8.3.5**. The test assemblies are manufactured by downhand arc deposition of metal to a plate with thickness of at least 20 mm made of steel of any grade/brand. Dimensions of the checking test assemblies shall ensure stability of the deposition process, as well as a possibility to produce four specimens to be tested for resistance to ICC and a possibility of repeated testing of the twice this number of specimens.

The need for heat treatment of the test assemblies before testing for resistance to ICC depends on the range of approval requested by the applicant (as required in **4.8.3.5.2**). The conditions and quantity of heat treatments for test assemblies to be tested for resistance of the deposited metal to ICC shall be additionally approved by the Register. As a rule, if a heat treatment after deposition of the main layer is permitted by the manufacturer of welding consumables or by the documentation for their application, the checking test assembly or blanks of specimens (prior to mechanical finishing) shall be subjected to two-time tempering at 630–650°C during 40 min with subsequent cooling in the air.

The arrangement for cutting of ICC specimens and dimensions of the deposit shall be in accordance with directions of Fig. 4.8.3.6.2.

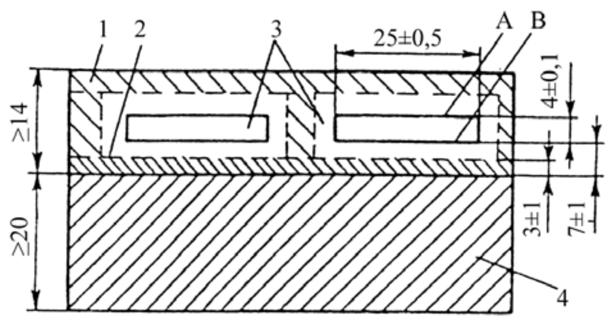


Fig. 4.8.3.6.2 Arrangements for cutting out the specimens when testing the deposited metal for resistance to ICC: 1 - deposited metal of the main layer; 2 - metal of deposited sublayer; 3 - blanks for preparation of specimens; 4 - base metal (plate); A and B - specimen surfaces

4.8.4 Methods of testing and evaluation of test results.

4.8.4.1 Determination of mechanical properties of deposited metal and welded joint.

Cut out from the deposited metal test assembly and tested shall be longitudinal cylindrical proportional specimens, shown in Fig. 2.2.2.3 (a), Part XIII "Materials" and having dimensions:

d_0 = 10mm, L_0 = 50mm, L_c = 60mm and $r \geq$ 5mm.

The longitudinal axis of the specimen shall coincide with the centre of the weld and the middle point of the metal deposit thickness. One specimen is required (when testing specimens with working part diameter of 6 mm, three specimens from each test assembly shall be tested).

The impact energy for deposited metal is determined on V-notch specimens meeting the requirements of **2.2.3**, Part XIII "Materials". The plan of specimens cutting out is shown in Fig. 4.2.3.2.2-1. Three specimens are taken from each test assembly.

A butt weld test assembly is employed for preparation and testing of:

2 transverse flat fracture specimens with dimensions as shown in Fig. 4.2.2.1;

2 transverse static bend specimens in accordance with Fig. 2.2.5.1, Part XIII "Materials" complying with the directions of 4.2.2.2.2 (specimen dimensions: $a_0 = t$ - thickness of the test assembly metal, b_0 = 30mm);

3 Charpy impact test specimens.

They shall be cut out as shown in Fig. 4.2.3.2-1, their type shall meet the requirements of 2.2.3, Part XIII "Materials".

For dissimilar welded joints, made with the use of welding consumables of Grade A-9sp or A-10sp, in static bending tests instead of transverse specimens longitudinal specimens shall be used, in compliance with Fig. 4.8.4.1. Length of the test assembly shall be sufficient for manufacture of such specimens.

General requirements for test procedures and for evaluation of test results are given in **4.2.3**, and criteria for evaluation of test results are contained in Tables 4.8.4.1-1 and 4.8.4.1-2.

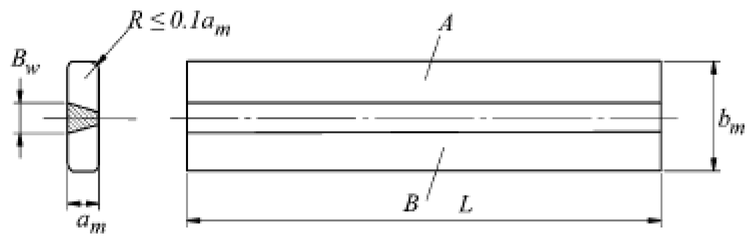


Fig.4.8.4.1. Specimen with longitudinal weld for static bend testing of metal of dissimilar welded joint:
A - part of the test assembly made of corrosion-resistant steel;
B - part of the test assembly made of higher or high strength hull structural steel;
$a_0 = t$ - thickness of base metal; b_0 = 30mm, but not less than (B_w + 24)mm;
$L \geq D_m + 9a_0 \approx 12a_0$, where D_m is diameter of mandrel used in bending tests.

Table 4.8.4.1-1 **Requirements for mechanical properties of deposited metal**

Grade of welding consumable	Designation of typical chemical composition of weld metal corresponding to base metal	Static tensile test				Impact test		Range of approval	
		$R_{p0,2}$, MPa	$R_{p1,0}$, MPa	R_m, MPa	A_5, %	Temperature, °C	*KV, J, min*	AISI/UNS	National steels
		min							
1	2	3	4	5	6	7	8	9	10
M-1	x20 Cr13, x30Cr13	410	–	650	16	+20	60	410, 420	20X13, 30X13
	x7CrNiNb 16 4	735	–	850	13	+20	60	–	07X16H4Б, 07X16H4
MF-2	x10CrNi 13 1	460	–	590	16	–10	20	414, 410S	08X14НДЛ, 05X12H2T
	x10CrNi 15 4	550	–	750	12	–10	30	429	08X15H4ДМЛ
	x15CrNi 17 2	540	–	690	16	+20	60	431	14X17H2
F-3	x8CrTi 17	360	–	480	16	+ 20	60	430T	08X17T
AM-4	x8CrNiTi 17 6	630	–	730	12	+ 20	60	–	08X17H6T
A-5	x3CrNi 19 10, x3CrNi 19 11	270	310	500	25	- 20 –196[1]	29 29	304L	03X18H11, 03X18H12
	x3CrNiN 19 10, x3CrNiN 19 11	305	345	530	22			304LN, 304L	Ditto
	x8CrNiNb 18 11, x8CrNiTi 18 11	290	330	550	22			321, 347, 304LN,304L	Ditto+08X18H10T , 08X18H12Б
A-6	x3 CrNiMo 19 11 3	270	310	500	22	-20 –196[1]	29 29	304L, 316L	03X18H11, 03X18H12, 03X17H14M3
	x3CrNiMo 19 13 4 , x3CrNiMoN 19 11 3	305	345	530	22			304LN, 304L, 316LN, 317L	Ditto
	x3CrNiMoN 19 13 4 , x8CrNiMoNb 19 11 3, x8CrNiMoTi 19 11 3,	340	380	570	22			321, 347, 304LN, 304L, 317LN, 316LN, 317L, 316Ti, 316Nb	Ditto+ 08X18H10T, 08X18H12Б
A-7ss	x2CrNiMoCu 21 25 5 2	270	310	500	22	-20	29	N08904 (904L)	–
	x2CrNiMoCu N 20 18 6 1	370	410	650	22	-60[2]		S31254	–
AF-8dup	x3CrNiMoN 22 5 3	450	490	620	25	–20[3]	40	S31803	03X22H6M2
	x3CrNiMoWCuN 25 7 3	485	525	690	20			S31260, S31803	08X22H6M2
	x4CrNiMoCuN 26 6 4 2; x3CrNiMoN 26 8 5; x3CrNiMoWCuN 26 8 4 1 1	550	590	780	20			S32550, S32750	, 08X21H6M2T -
A-9sp (special)	x2CrNi 24 12, x10CrNi 24 12, x8CrNiMo 23 13, x10CrNiMo 24 13 2 and the like	350	420	520	22	-20	29	Dissimilar welded joints. Intermediate (transition) layers for stainless liners including intermediate runs of clad steel joints. Welding of type 309, 309L, 309Mo, 309S and 309SCb steels	
A-10sp (special)	x8CrNiMoN 16 25 6 x8CrNiMoVN 16 25 6 1	390 490	– –	610 680	26 26	+20 +20	80 80	For welding: of heterogeneous welds; intermediate passes of connections of cladding steel; deposition of the intermediate (transitional) sublayer. Welding of grade M-1, MF-2, F-3 and AM-5 steels, as well as limited weldability steels without heating.	
	xlCrNi 26 22 , x10CrNi 26 22	390	–	550	26	-20	29	Ditto+welding of type 310 and 310Mo steels	

[1] Tests at a temperature of -196°C are carried out only if required by the Register based on the manufacturer's request to record in the Certificate of Approval for Welding Consumables the extended range of approval.

[2]Tests at a temperature of -60°C are carried out only if required by the Register based on the manufacturer's request to record in the Certificate of Approval for Welding Consumables the extended range of approval.

[3]In accordance with the manufacturer's request, tests at a lower temperature may be carried out to record in the Certificate of Approval for Welding Consumables the extended range of approval.

Table 4.8.4.1-2. **Requirements for mechanical properties of butt welded joint metal**

Grade of welding consumable	Base metal for testing			Static tensile test R_m, MPa, min	Impact test		Bend test		
	Designation of typical composition	Brands			Temperature, °C	*KV, J*, min	Specimen type	Mandrel diameter	Bend angle, deg., min
		AISI/ UNS	National steels						
1	2	3	4	5	6	7	8	9	10
M-1	x20Cr13, x30Cr13	410, 420	20X13, 30X13	650	+20	60	Transverse	5*t*	120
	x7CrNiNb 16 4	–	07X16H4Б, 07X16H4	850	+20	60	Transverse	5*t*	120
MF-2	x10CrNi 13 1	414, 410S	08X14НДЛ, 05X12H2T	590	–10	20	Transverse	6*t*	120
	xl0CrNi 15 4	429	08X15H4ДМЛ	750	–10	30	Transverse	5*t*	120
	xl5CrNi 17 2	431	14X17H2	690	+20	60	Transverse	5*t*	120
F-3	x8CrTi 17	430T	08X17T	480	+20	60	Transverse	5*t*	120
AM-4	x8CrNiTi 17 6	–	08X17H6T	730	+20	60	Transverse	5*t*	120
A-5	x3CrNi 19 11	304L	03X18H11, 03X18H12	500	–20 -196[2)]	27	Transverse	3*t*	120
	x3CrNiN 19 11	304LN	-	530					
	x8CrNiTi 18 11	321	08X18H10T	550					
	x8CrNi Nb 18 11	347	08X18H12Б	550					
A-6	x3CrNiMo 19 11 3	316L	03X17H14M	500	–20 -196[2)]	27	Transverse	3*t*	120
	x3CrNiMo 19 13 4	317L	-	530					
	x3CrNiMoN 19 11 3	316LN	-	530					
	x3CrNiMoN 19 13 4	317LN	-	570					
A-7ss	x2CrNiMoCu 21 25 5 2	N08904 (904L)	-	500	-20[3)]	27	Transverse	3*t*	120
	x2CrNiMoCu 20 18 6 1	S31254	-	650					
AF-8dup	x3CrNiMoN 22 5 3	S31803	03X22H6M2, 08X22H6M2	620	-20 -60[3)]	40	Transverse	3*t*	120
	x3CrNiMoWCuN 25 7 3	S31260	08X21H6M2T	690				4*t*	
	x4CrNiMoCuN 26 6 4 2	S32550	-	760				6*t*	
	x3CrNiMoN 26 8 5	S32750	-	800				6*t*	
	x3CrNiMoWCuN 26 8 4 1 1	S32760	-	750				6*t*	
A-9sp	x8CrNi 24 14	309	-	515	-20	27	Transverse	3*t*	120
	Dissimilar, e.g. D40 + A-6 etc.			Не менше R_m основного металу			Transverse		
A-10sp	Dissimilar, e.g. D40 + A-6 etc.				4)	4)	Transverse	3*t*	120

[1)] *t* – thickness.

[2)]Tests at a temperature of -196°C are carried out only on the Register's special demand based on the manufacturer's request to record in the Certificate of Approval for Welding Consumables the extended range of approval.

[3)]In accordance with the manufacturer's request, tests at a lower temperature may be carried out to record in the Certificate of Approval for Welding Consumables the extended range of approval.

[4)]The test temperature and criteria for evaluating the test results shall meet the minimal requirements for welding consumables for the base metal.

4.8.4.2 Static bend tests for specimens with cladding deposit.

Tested by static bend shall be three specimens with cladding deposit and with loading arrangements aimed at load application parallel to the bond surface (side bend) and perpendicular to the direction of welding in the process of deposition.

Dimensions of the specimens and parameters of testing shall comply with the data shown in Fig. 4.8.4.2.

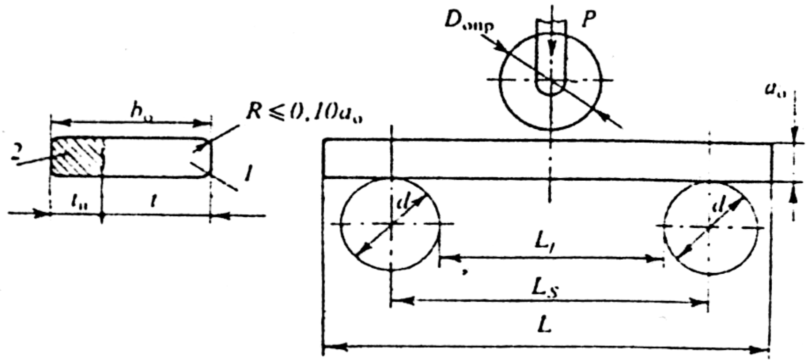


Fig. 4.8.4.2 Specimen with cladding deposit for side-bend testing 1 - base metal, 2 - cladding deposit; $a_0 = 10^{+0,1}$mm is thickness of the specimen, $b_0 = t + t_p \leq 35$mm is width of the specimen (where t is thickness of the base metal; $6 \leq t_p \leq 10$ is thickness of the cladding deposit)); $D_m = 3a_0 = 30$mm is diameter of bending mandrel; $d = 30$mm is diameter of supporting rollers, $L_1 = D_m + 3a_0 = 60$mm is free interval between the rollers; $L \geq 160$mm is length of the specimen; $R \leq 0{,}1a_0$ is permissible radius of rounding-off of specimen's free edges; P is bending load applied to the specimen

It is recommended to take test specimens by mechanical cutting. In case of using the isolating plasma cutting the allowance for machining shall be such as to make the specimen completely free from heat affected zone. The test procedure shall consist of two stages:

static bend to an angle of about 90° with recording of the intermediate test result (without dismantling of the specimen);

continuation of the test until the final bend angle (not less than 120° is obtained, dismantling of the specimens, recording of the test result.

If, prior to obtaining the required bend angle, and inadmissible crack appears in the test zone, the testing shall be stopped. The following defects are considered inadmissible during this type of tests:

transverse cracks of 3 mm and more in length;

longitudinal discontinuities opening in the process of specimen bending and having a length equal to 20 % or more of the specimen width.

4.8.4.3 Tests defining resistance to intercrystalline corrosion.

4.8.4.3.1 The tests intended to define resistance of the weld metal and deposited metal to intercrystalline corrosion shall be carried out observing the requirements of national or international standards specifying immersion of the specimens in boiling aqueous solution of copper sulphate and sulphuric acid in presence of copper as metal with subsequent bending of the specimens to 90° angle in order to reveal indications of intercrystalline corrosion (Strauss method). At initial approval of welding consumables a variety of this method shall be used, in which the specimens are immersed in the boiling solution for at east 24 h; at repeated tests it is permissible, according to the test program approved by the Register, to employ an accelerated test procedure, with the specimens kept in the boiling solution for a period from 8 to 15 h.

4.8.4.3.2 Unless otherwise agreed upon with the Register, the dimensions of specimens for ICC testing (refer to Fig. 4.8.4.3.2) and diameters of bending mandrels shall correspond to values in Tables 4.8.4.3.2-1 and 4.8.4.3.2-2.

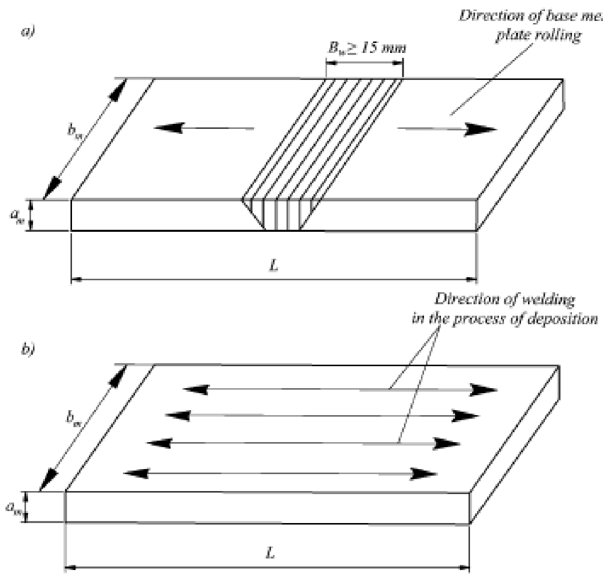


Fig. 4.8.4.3.2 sistance to intercrystalline corrosion:
a - of weld metal in the welded joint; ***b*** - of deposited metal in the cladding deposit

Table 4.8.4.3.2-1 **Dimensions of specimens and diameters of mandrel rounding-off when testing weld metal for resistance to ICC**

Grades of welding consumables	Specimen thickness *a*, mm	Specimen width *b*, mm	Specimen length *L*, mm	Mandrel diameter, mm
A-5, A-6, A-7, A-9sp	6 ± 0,1	20 ± 0,5	≥ 100	20
AF-8	5 ± 0,1	20 ± 0,5	≥ 100	20
F-3	5 ± 0,1	20 ± 0,5	≥ 100	30
AM-4, MF-2, M-1	3 ± 0,1	20 ± 0,5	≥ 80	20

Table 4.8.4.3.2-2 **Dimensions of specimens and diameters of mandrel rounding-off when testing deposited metal for resistance to ICC**

Grades of welding consumables	Specimen thickness *a*, mm	Specimen width *b*, mm	Specimen length *L*, mm	Mandrel diameter, mm
A-5, A-6, A-9sp	4 ± 0,1	20 ± 0,5	≥ 100	20
AF-8	4 ± 0,1	20 ± 0.5	≥ 100	20

The resistance of weld metal to ICC is evaluated on the basis of test results obtained from three specimens subjected to tensioning of the weld top layer, which corresponds to testing of the base metal plate initial surface (not subjected to machining intended for reduction of specimen thickness). In this case the plane of bending load application (axis of mandrel) shall coincide with the weld axial line.

Note. Bending with application of the load within the heat affected zone is employed for testing of corrosion-resistant steels and for approval of welding procedures.

The resistance of cladding layer metal to ICC is evaluated on the basis of test results obtained from four specimens cut out in accordance with the directions of Fig. 4.8.3.6.2; of these specimens:

two specimens are tested by tensioning the top surface A (top surface) of the deposit;

two specimens are tested by tensioning the top surface B (bottom surface) of the deposit.

4.8.4.3.3 The bent specimens shall be inspected using a magnifying glass with 8-12X magnification. Absence of cracks in the specimen, apart from longi-tudinal cracks and cracks directly on the edges, is a proof of resistance to ICC.

In questionable cases the resistance to ICC is additionally estimated by a metallographic method. In this case from a non-bent portion of the specimen after corrosion testing a wafer is cut to obtain a microsection; the plane of the cut shall be normal to the weld and contain the weld metal and heat affected zone. The presence and depth of intercrystalline corrosion is established on etched sections using 200X magnification. The maximum depth of corrosive attack is revealed in six fields of vision, which shall include portions with largest depth of ICC. The specimen is considered corrosion (ICC) - resistant, if the decay at grain boundaries has the maximum depth not exceeding 30 micron.

4.8.4.3.4 The result of the test for resistance to ICC is considered satisfactory, if the ICC is not detected on any of the tested specimens. If one of the tested specimens yields unsatisfactory results, the tests shall be repeated, as required by national or international standards.

If at the initial tests more than one specimen proved to be unsatisfactory, or if the repeated tests produced negative results, the weld or deposited metal is considered as having failed the tests for resistance to ICC.

Note. In ambiguous cases for materials susceptible to cracking it is recommended to carry out, as a reference check, bending tests for specimens, similar to ICC-tested, but not subjected to boiling in aqueous solution of sulphuric acid and copper sulphate.

4.8.4.4 Check of a-phase (ferrite component).

Inspection of a-phase (ferrite component) in the weld metal and cladding layer is determined in welding consumables of Grades A-5, A-6, AF-8 and A-9sp using the following methods of measurement:

.1 local non-destructive testing method, where the a-phase content is estimated as the mean value of at least 10 measurements for butt-welded joint assemblies, also for assemblies with cladding deposits, as specified in **4.8.3.5** and **4.8.3.6**;

.2 if the above measurement method produced inadequate results, or in accordance with a special requirement of the Register, a check analysis is performed by the volumetric magnetic method with the use of ferritemeters, which make measurements with error not exceeding ±10% of the measured value.

The analysis for determination of a-phase content with the aid of volumetric magnetic method requires a seven-layer deposition with welding consumables analyzed to a corrosion-resistant steel plate, which in its grade and chemical composition corresponds to the above consumables.

From the two top layers of deposited material pilot cylindrical specimens are cut having a length of (60 ± 1) mm and diameter of (5 ± 0,1) mm, as shown in Fig. 4.8.4.4.

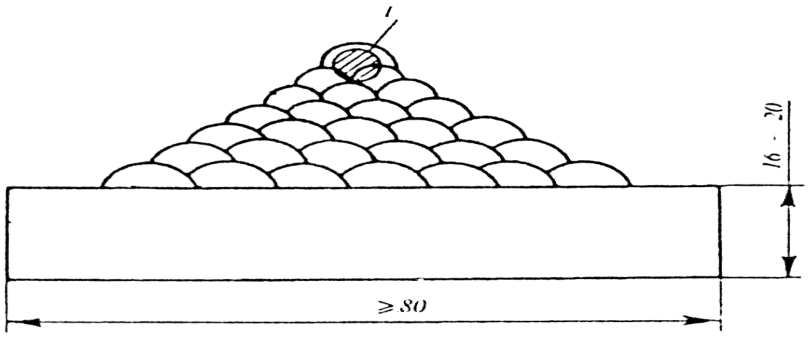


Fig. 4.8.4.4. Arrangements for cutting out specimens intended to determine α-phase content by volumetric magnetic method:
1 – place for cutting out check specimens

The controlled values of α-phase content shall meet the requirement of technical documentation approved by the Register or specified by respective national standards for particular welding consumables.

The results of check measurements of α-phase content in the weld metal and/or cladding layer shall be recorded in the Test Report.

4.8.4.5 Determination of chemical composition of deposited metal.

The test assemblies for determination of chemical composition of deposited metal shall be taken from metal of two top layers; these are:

test assembly of deposited metal;

test assembly of multilayer deposit taken in accordance with Fig. 4.8.3.6.2 (for compositions "strip - flux" the test assemblies for determination of chemical composition are taken from deposited metal only).

The results of determination of deposited metal chemical composition shall comply with tolerances claimed by the manufacturer and shall be recorded in the Test Report.

4.8.5 Tests for confirmation of Certificate of Approval for Welding Consumables.

The program of annual re-approval test of welding consumables for corrosion-resistant steels welding and deposition shall include:

.1 manufacture of deposited metal assembly and testing of specimens, static tensile and impact bend as well as checking chemical analysis of the deposited metal;

.2 determination of resistance of weld metal or deposited metal to ICC, if this is required for a particular brand of welding consumable.

If required by the Register, the scope of annual tests may be extended and supplemented by other types of testing or preparation of additional test assemblies.

4.9 WELDING CONSUMABLES FOR ALUMINIUM ALLOYS

4.9.1 General.

4.9.1.1 The requirements of this Section specify the conditions of approval and survey of welding consumables intended for hull construction and other structure aluminium alloys complying with the requirements in **5.1**, Part XIII "Materials".

When the special requirements are lacking, the similar requirements for approval of the welding consumables for welding normal and higher strength hull structural steels shall apply.

4.9.1.2 The welding consumables intended for fabrication of aluminium alloy structures are divided into two categories as follows:

W - wire electrode and "wire - gas" combinations for metal arc inert gas welding ((MIG, 131 according to ДСТУ ISO 4063 or ISO 4063), tungsten inert gas arc welding (TIG, 141) or plasma arc welding (15);

R - rod - gas combinations for tungsten inert gas arc welding (TIG, 141) or plasma arc welding (15).

4.9.1.3 Grading and designation.

The welding consumables are divided into grades according to Tables 4.9.1.3-1 and 4.9.1.3-2 for the international and national alloys, respectively, considering the composition and strength level of the base metal used for the approval tests.

Table 4.9.1.3-1 **Grades of welding consumables for international aluminium alloys**

Grade	Base metal for tests and alloy designation	
	Numerical code	Chemical symbol
RA/WA	5754	AlMg3
RB/WB	5086	AlMg4
RC/WC	5083	AlMg4,5Mn0,7
	5383	AlMg4,5Mn0,9
	5456	AlMg5
	5059	–
RD/WD	6005A	AlSiMg (A)
	6061	AlMg1SiCu
	6082	AlSilMgMn

Table 4.9.1.3-2 **Grades of welding consumables for national aluminium alloys**

Grade	Base metal for tests and alloy designation	
	Numerical code	Chemical symbol
Rl/W1	1530	AlMg3,5Si0,6
R2/W2	1550	AlMg5,0Mn0,6
R3/W3	1561	AlMg6,0Mnl
R3/W3	1565ч	AlMg6,0Mnl
R4/W4	1565ч	AlMg6,0Mn0,5Sc
R4/W4	1575	AlMg6,0Mn0,5Sc
R5/W5	–	AlSiMgMn
Note. Approval of higher strength AlMg base materials also covers the lower strength AlMg grades and their combinations.		

The consumable grade designation shall include:

designation of the welding consumable group (W or R);

designation of the group of the base metal used for the approval tests (A, B, C and D for international alloys or 1, 2, 3, 4 and 5 for national alloys);

numerical code of the grade of the base metal used for the approval tests given in brackets. For example: RC(5446), W3(1561), etc.

4.9.1.4 Approval of a wire or a rod shall be granted in conjunction with a specific shielding gas according to Table 4.9.1.4 or defined in terms of composition and purity of "special" gas to be designated with group sign "S". The shielding gas composition shall be entered in a test report and the Certificate of Approval for Welding Consumables/Certificate (C). The approval of the wire with any particular gas can be applied or transferred to any combination of the same wire and any gas in the same numbered group as defined in Table 4.9.1.4. For special gases designated with sign "S" the approval is valid only for the specific composition and purity of the shielding gas or mixture used in testing.

4.9.1.5 l procedure and the requirements for manufacturers shall comply with **4.1.3**.

The requirements for test procedure and results evaluation shall comply with the requirements in **4.2**.

Table 4.9.1.4

Designation of typical composition group	Shielding gas composition, vol. % [1]	
	Argon	Helium
I-1	100	–
I-2	–	100
I-3	Rest	> 0 up to 33
I-4	Rest	> 33 up to 66
I-5	Rest	> 66 up to 95
S	Gases, which composition and purity differ from typical composition groups I-1 to I-5	

[1] Gases of other chemical composition (mixed gases) may be considered as "special gases" (are designated with sign "S") and covered by the results of separate tests for each specific composition.

4.9.2 Deposited metal tests.

The test assembly as shown in Fig. 4.9.2 shall be welded in a downhand position for chemical analysis of the deposited metal. The assembly dimensions, which depend on the type of the welding consumables and the degree of the welding procedure mechanization, shall provide a sufficient amount of deposited metal for chemical analysis. The base metal shall be compatible with the weld metal in respect of the chemical composition. The results of the chemical analysis including the main alloying elements and impurities shall be within the limits specified by the manufacturer.

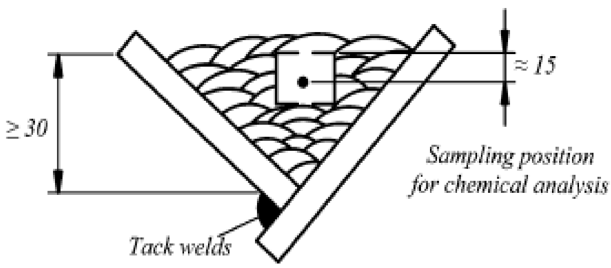


Fig.4.9.2 Deposited metal test assembly

4.9.3 Butt weld tests.

4.9.3.1 The testing of butt welded joints shall be carried out on the test assemblies according to Figs. 4.9.3.1-1 and 4.9.3.1-2 similar to **4.3.3.1**, **4.3.3.2**, **4.5.2.3.1**, **4.5.3.3.1** or **4.5.4.2.1**, depending on the type of welding consumables and the degree of the welding procedure mechanization respectively. The base metal corresponding to the welding consumables grade to be approved according to Tables 4.9.1.3-1 or 4.9.1.3-2 shall be used for preparation of the test assemblies.

4.9.3.2 One butt weld test assembly according to Fig. 4.9.3.1-1 having thickness 10 to 12 mm shall be prepared in each welding position (downhand, vertical-upward, vertical-downward, horizontal-vertical and overhead), for which the consumable is recommended by the manufacturer.

In this case the welding consumables satisfying the requirements for downhand and vertical-upward positions may be considered as also complying with the relevant requirements for the horizontal-vertical position.

4.9.3.3 Additionally one test assembly according to Fig. 4.9.3.1-2 having thickness 20 to 25 mm shall be prepared and welded only in the downhand position.

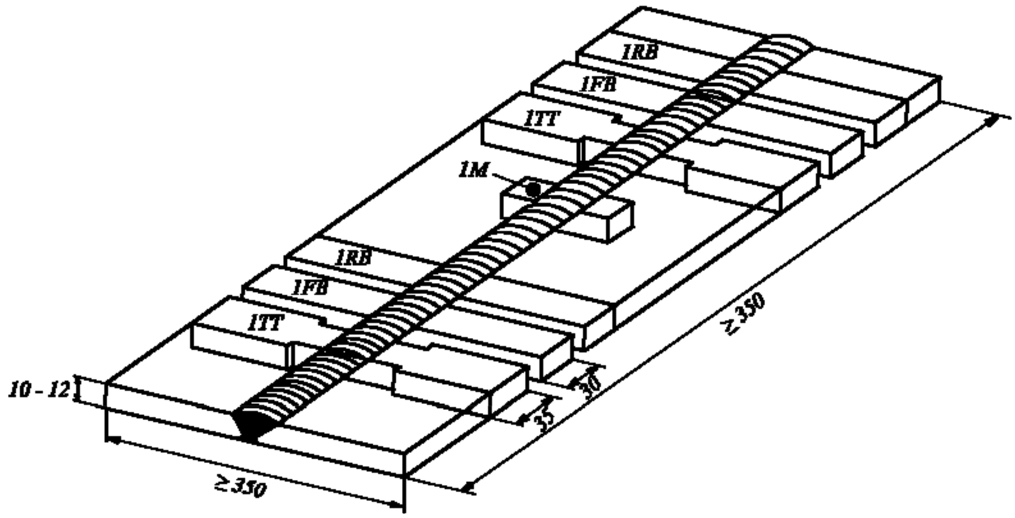


Fig. 4.9.3.1-1 Butt weld test assembly for welding in various welding positions: edge preparation shall be V-single or V-double with 70° angle;
back sealing runs are allowed in single V weld assemblies; in case of V-double assembly, both sides shall be welded in the same welding position; specimens are designated according to **4.9.3.5**.

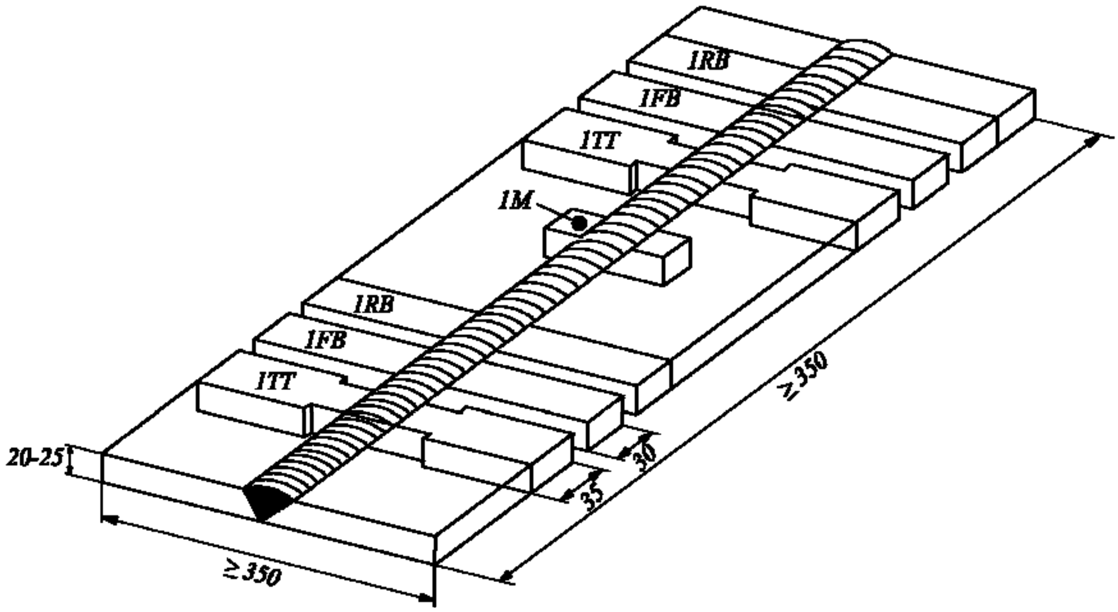


Fig. 4.9.3.1-2 Additional butt weld test assembly for welding in downhand position: edge preparation shall be V-single with 70° angle;
back sealing runs are allowed; specimens are designated according to 4.9.3.5.

4.9.3.4 On completion of welding, the test assemblies shall be allowed to cool naturally to the ambient temperature. For grade D welding consumables, the test assemblies shall be allowed to naturally ageing for a minimum period of 72 h from the completion of welding before testing is carried out.

4.9.3.5 The following types of test specimens shall be taken from each butt weld test assembly and tested as shown in Figs. 4.9.3.1-1 and 4.9.3.1-2:

2TT - two transverse flat tensile test specimens;

2RB - two transverse root bend test specimens;

2FB - transverse face bend test specimens;

1M - transverse macrosection.

4.9.3.6 The mechanical properties of butt welded joints shall meet the requirements in Table 4.9.3.6.

***4.9.3.6.* Requirements for mechanical properties of butt welded joints**

Grade of welding consumable	Numerical code of base metal for testing	Tensile strength R_m, MPa, min	Bend test	
			Mandrel diameter *D*[1]	Bend angle[2], deg.
1	2	3	4	5
International alloys				
RA/WA	5754	190	3*t*	180
RB/WB	5086	240	6*t*	
RC/WC	5083	275	6*t*	
	5083 або 5456	290	6*t*	
	5059	330	6*t*	
RD/WD	6061, 6005A або 6082	170	6*t*	
National alloys				
R1/W1	1530	185[3]	6*t*	180
R2/W2	1550	275[3]	6*t*	
R3/W3	1561	305	6*t*	
R3/W3	1565ч	305[3]	6*t*	
R4/W4	1565ч	335[3]	6*t*	
R4/W4	1575	360	6*t*	
R5/W5	(AlSilMgMn)	170	6*t*	

[1] *t* - specimen thickness during test;
[2] When evaluating the test results, one should be guided by the following:
no any single crack of over 3 mm long in any direction is allowed on the specimen surface;
cracks at the corners of a test specimen may be ignored in the evaluation, unless there is evidence that they result from lack of fusion.
[3] For welded joints of up to 12,5 mm thick inclusive.

6 The mechanical properties of butt welded joints shall meet the requirements in Table 4.9.3.6. The test procedure and results evaluation, including repeated and annual tests, shall comply with the relevant requirements in **4.2**. The position of a fracture on tensile test specimens shall be recorded in a test report. The macrosections shall be examined for defects such as a lack of fusion, cavities, inclusions, pores or cracks. At that the bending tests are performed with the "wrap around bending method" as shown in Fig. 4.9.3.6.

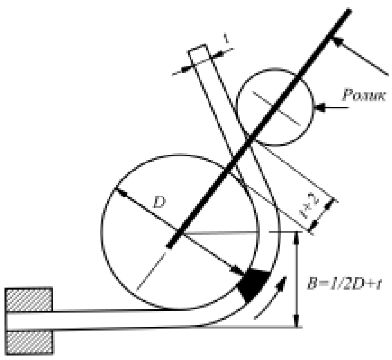


Fig. 4.9.3.6 Sketch of wrap around bend test

4.9.4 Annual tests.

4.9.4.1 The annual tests to endorse the Certificate of Approval for Welding Consumables shall include the preparation and testing of the deposited metal test assembly as prescribed under 4.9.2 (refer to Fig. 4.9.2) and of one butt weld test assembly having thickness 10 to 12 mm in a downhand welding position according to 4.9.3 (refer to Fig. 4.9.3.1-1).

4.10 WELDING CONSUMABLES FOR TITANIUM ALLOYS

4.10.1 General.

4.10.1.1 The requirements of this Section specify the conditions of approval and survey of welding consumables to be used for hull and other structures of titanium alloys as per the requirements of Section 9 of Part XIII "Materials". Where no special requirements are given herein, those for the approval of welding consumables for normal and higher strength hull structural steels shall apply in analogous manner.

4.10.1.2 The welding consumables to be used for fabricating titanium alloy structures are divided into two categories as follows:

W – wire electrode and "wire - gas" combinations for consumable electrode inert gas arc welding (MIG, 131 according to ISO 4063), tungsten inert gas arc welding (TIG, 141) or plasma arc welding (15);

R – rod - gas combinations for consumable electrode inert gas arc welding (TIG, 141).

4.10.1.3 Grading and designation.

The welding consumables are graded into categories considering the composition and strength level of the base metal used for the approval tests as per Table 4.10.1.3.

The welding consumable grade designation shall include:

Ti index to indicate the functionality of welding consumables;

designation of the welding consumables group (W or R);

designation of the strength group of a welded joint (metal used for the approval tests) - A, B;

letter designation of the welding consumable (alloy) brand in parenthesis. Examples: TiWA(ВТ1-00св), TiRB (2В), TiRB(ПТ-7Мсв).

Table 4.10.1.3

Welding consumable grade		Letter designation of the welding consumable brand	Base material for the tests	Range of approval
Wire	Rod-gas combinations			
TiWA	TiRA	ВТ1-00св	ВТ1-0	ВТ1-0, ВТ1-00
TiWB	TiRB	2В	ПТ-3В	ВТ100, ВТ1-00, ПТ-1М, ПТ-7М, ПТ-3В
		ПТ-7Мсв[1]	ПТ-7[1]	ВТ1-0, ВТ1-00, ПТ-1М, ПТ-7М
[1] Approval of welding materials exclusively for welding alloys used solely for the manufacture of pipes is carried out in within the framework of requirements for the approval of welding procedures for butt joints of pipes with diameter $D \leq 25$mm and $D \geq 80$mm and wall thickness $t \leq 3$mm and $t \geq 10$mm, accordingly, in one of the (spatial) welding positions (refer to Section **8**).				

4.10.1.4 Approval of a wire or a rod shall be granted in conjunction with a specific shielding gas type composition group according to Table 4.9.1.4 or defined in terms of composition and purity of "special" gas to be designated with group sign "S". The shielding gas composition shall be entered in a test report and the Certificate of Approval for Welding Consumables/Certificate (C). The approval of the wire with any particular gas can be applied or transferred to any combination of the same wire and any gas in the same numbered type composition group as defined in Table 4.9.1.4. For special gases designated with sign "S" the approval is valid only for the specific composition and purity of the shielding gas or mixture used in testing.

4.10.1.5 The approval procedure and the requirements for manufacturers shall be in accordance with **4.1.3**.

The requirements for test performance and results evaluation shall comply with the provisions in **4.2.**

4.10.2 Deposited metal test.

The test assembly as shown in Fig. 4.10.2 shall be prepared and welded in a downhand position for determining the chemical composition of the deposited metal.

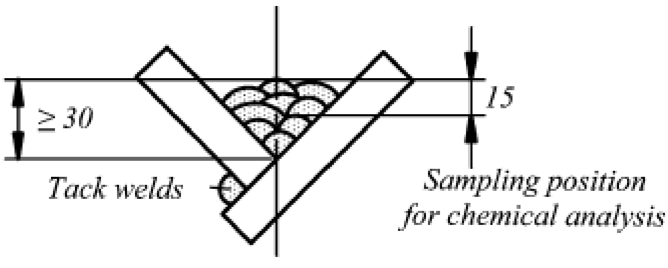


Fig.4.10.2 Deposited metal test assembly

The test assembly dimensions shall allow the flow of the welding process in a steady mode as well as a sufficient quantity of pure deposited metal for chemical analysis. In any case the length of the test assembly shall be at least 150 mm for manual welding processes and at least 300 mm for mechanized welding.

The base metal shall be compatible with the weld metal in respect of chemical composition. The results of the chemical analysis in main alloying elements and impurities shall be within the limits specified by a manufacturer. The chemical composition of a deposited metal shall be determined by the methods, specified standards or procedures agreed upon with the Register. The quantity of the test assemblies made of deposited metal shall be determined taking into account the range of diameters of welding wire (rod) to be approved by the Register. Herewith, the recommendations given in Table 4.2.10 shall be complied with.

Table 4.10.2

Welding procedure	Welding type	Diameter of welding wire (rod), mm,	
		to be approved	used for the deposited metal test assembly welding
Automatic	131	0,8 to 3,0	any
Manual	141	1,2 to 6,0	1,6 and 4,0
Automatic	141	1,2 to 4,0	1,6 and 3,0

4.10.3 Butt weld tests.

4.10.3.1 The testing of butt welded joints shall be carried out on the test assemblies according to Figs. 4.10.3.1-1 and 4.10.3.1-2 in an analogous manner to **4.3.3.1** and **4.3.3.2**, **4.5.2.3.1**, **4.5.3.3.1** or **4.5.4.2.1** depending on the type of welding consumables and degree of the welding procedure mechanization respectively. The base metal in compliance with the approved welding consumable grade according to Table 4.10.1.3 shall be used for test assemblies preparation.

4.10.3.2 One butt weld test assembly according to Fig. 4.9.3.1-1 with a thickness of 10 to 12 mm shall be prepared and welded n each welding position (downhand, vertical-upward, vertical-downward, horizontal-vertical and overhead) for which the consumable is recommended by a manufacturer according to Fig. 4.10.3.1-1.

In this case the welding consumables satisfying the requirements for downhand and vertical-upward positions may be considered as also complying with the relevant requirements for the horizontal-vertical position.

4.10.3.3 Additionally one test assembly according to Fig. 4.10.3.1-2 with a thickness of 20 to 25 mm shall be prepared and welded in the downhand position only. Recommended forms of preparation are set forth in Table 4.10.3.3.

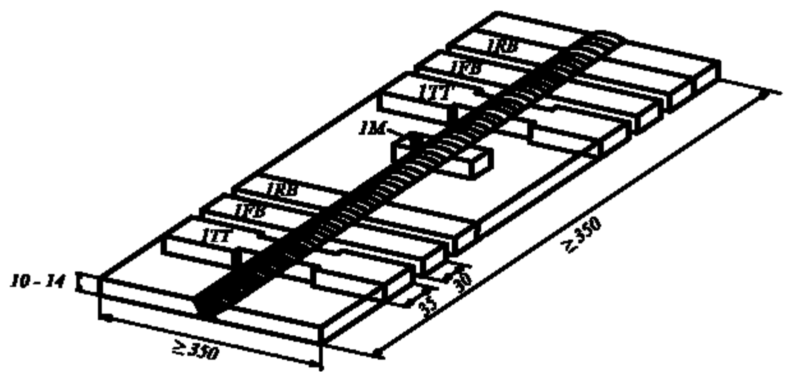


Рис. 4.10.3.1-1 Butt weld test assembly for welding in various welding positions:
specimens are designated according to **4.10.3.5**. Edge preparation shall be single V or double V with 50° angle (refer to Table 4.10.3.3).

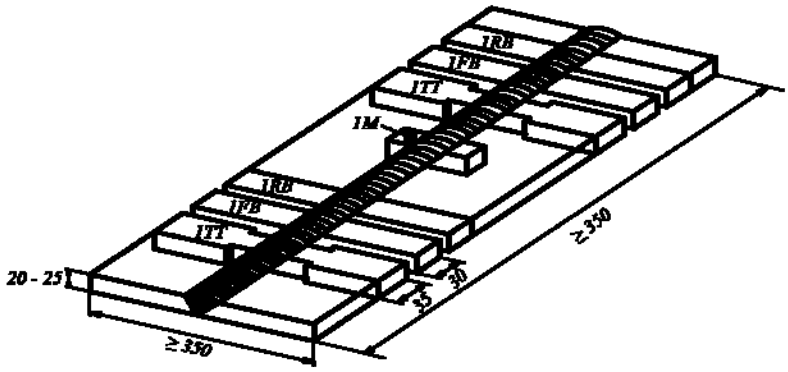
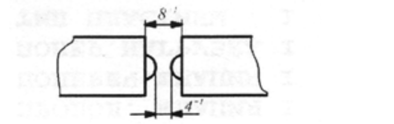
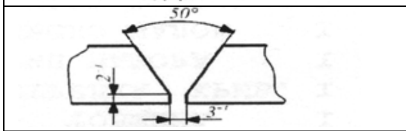
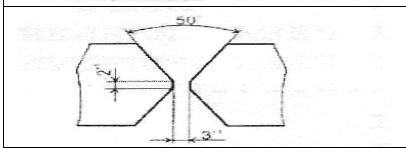


Fig. 4.10.3.1-2 Additional butt weld test assembly for welding in downhand position: specimens are designated according to **4.9.3.5**. Edge preparation shall be carried out according to Table 4.10.3.3

Table 4.10.3.3

The edge preparation details	Welding type	Діаметр дроту, мм
	141- manual	Root of a weld - 3 mm Filling pass - 4÷ 6
	141- manual	Root of a weld - 3 mm Filling pass - 4÷ 6
	141- manual 131 or 141 - automatic	Root of a weld - 3 Filling pass – 1,2÷ 2
	141- manual	Root of a weld - 3 mm Filling pass - 4÷ 6
	141- manual 131 or 141 - automatic	Root of a weld - 3 Filling pass – 1,2÷ 2

4.10.3.4 The test assembly length shall provide a steady flow of the welding procedure in the maintaining mode and manufacture of the required quantity of test assemblies.

The welded joints test assembly techniques if otherwise is not agreed with the Register, shall provide the root pass with manual argon-arc welding with the formation of the weld reverse side using a wire with a diameter of 3 mm. Filling-up of the groove and a back run shall be carried out taking into account the recommendations of Table 4.10.3.4.

Table 4.10.3.4

Welding procedure and type	Mechanised consumable electrode inert gas arc welding ДСТУ ISO 4063 or ISO 4063	Welding consumable test assembly thickness			
		10 to 14 mm		20 to 25 mm	
		Diameter, mm		Diameter, mm	
		additives	cons. electrode	additives	cons. electrode
Mechanised consumable electrode inert gas arc welding	131	1,0 ÷ 1,2	-	1,6 ÷ 2,0	-
Mechanised consumable electrode inert gas arc welding	141	3,0 or 4,0	3,0	5,0 or 6,0	4,0
Automatic tungsten inert gas welding — TIG	141	1,2 or 1,4	2,5 ÷ 3,0	1,6 or 2,0	3,0 ÷ 4,0

Test assembly welding modes shall comply with the manufacturer's recommendations or technological documentation for the welding of titanium alloys.

4.10.3.5 From each butt weld test assembly as per Figs. 4.10.3.1-1 and 4.10.3.1-2 the following types of specimens shall be selected and tested:

two transverse flat tensile test specimens (TT);

two transverse root bend test specimens (RB);

two transverse face bend test specimens (FB);

one transverse macrosection (M).

4.10.3.6 The mechanical properties of butt welded joints shall meet the requirements in Table 4.10.3.6. The test performance and results evaluation including repeated and annual tests shall comply with the relevant requirements in **4.2**. The position of a fracture on tensile test specimens shall be included in a test report. The macrosections shall be examined to check for the presence of imperfections like lack of fusion, cavities, inclusions, pores or cracks.

Table 4.10.3.6

Welding consumable grade	Base metal grade	Tensile strength R_m, MPa, min	Bend test	
			Mandrel diameter	The bending angle, degrees,[1] at least
TiWA/TiRA	ВТ1-0	370	6*t*	180
TiWB/TiRB	ПТ-3В	640	8*t*	180
	ПТ-7М	480	8*t*	180
[1] The cracks of length less than 3 mm on the specimen side being in tension are not taken into consideration. *Note: t* – the specimen's thickness.				

4.10.4 Annual tests.

The annual tests to endorse the COCM shall include the preparation and testing of the deposited metal test assembly as prescribed in **4.10.2** (refer to Fig. 4.10.2) and of one butt weld test assembly of 10 to 14 mm thick in a downhand welding position according to **4.10.3** (refer to Fig. 4.10.3.1-1).

5. APPROVAL TEST FOR WELDERS

5.1 GENERAL

5.1.1 Welding of structures and products subject to technical supervision of the Register according to the requirements of 1.1.1 shall be performed by the welders, who have passed the respective tests and been admitted to the welding operations by the Register.

5.1.2 The testing procedure for the welders of manual and partially mechanized welding with drawing up a Welder Approval Test Certificate shall meet the requirements of Section **4**, Part III "Technical supervision during manufacture of materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

The welders who have passed the tests according to the international and/or national standards (ДСТУ EN ISO 9606, EN ISO 9606, ISO 9606, ASME Sec.IX, ANSI/AWS D1.1), may be admitted to the welding operations.

5.1.3 The testing procedure for the welders of completely mechanized welding with drawing up a Welder Approval Test Certificate shall meet the requirements of Section 4, Part III "Technical supervision during manufacture of materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships or the respective international and national standards recognized by the Register including ДСТУ EN ISO 14732 and the applicable ISO and EN standards.

When it is stipulated by Contract terms, the certification and approval of the welders for automatic and robot welding shall be performed according to the procedural requirements equivalent to ДСТУ EN ISO 14732 or the applicable ISO and EN standard.

5.1.4 In all the cases listed in **5.1.2** and **5.1.3**, the test results on welding procedure approval performed by the welder to be certified, can be considered as practical tests on welders' approval.

5.1.5 Recognition of documents confirming the qualification of welders and issued by another classification society or authorized competent authority shall be determined in each case by the Register during technical supervision for ships under construction or manufacture of products in the scope sufficient to confirm compliance of these documents with the requirements of Section **4**, Part III "Technical supervision during manufacture of materials" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships.

5.1.6 Terms for validity and extension of the Welder Approval Test Certificate shall comply with the requirements of Section 4, Part III Technical supervision during manufacture of materials" of the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships or the international and/or national standards, including ДСТУ EN ISO 9606 and ДСТУ EN ISO 14732 and the applicable ISO and EN standards, ASME Sec. IX, ANSI/AWS D1.1.

6. APPROVAL OF WELDING PROCEDURES FOR WELDING OF STEEL STRUCTURES AND PRODUCTS

6.1 GENERAL

6.1.1 The welding procedures adopted for the manufacture of structures subject to survey by the Register, which are mentioned in 1.1.1, shall be approved by the Register and shall comply with the requirements of Section **6**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

7. APPROVAL OF WELDING PROCEDURES FOR ALUMINIUM ALLOYS

7.1 GENERAL

7.1.1 Welding procedure approval used for the manufacture of the aluminium alloy structures subject to survey by the Register shall be approved by the Register and comply with Section **7**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

8. APPROVAL OF WELDING PROCEDURES FOR TITANIUM ALLOYS

8.1 GENERAL

8.1.1 Welding procedure used for the manufacture of the titanium alloy structures subject to survey by the Register shall be approved by the Register and comply with Section **8**, Part III "Technical Supervision during Manufacture of Materials" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

Shipping Register of Ukraine

RULES
FOR THE CLASSIFICATION AND CIONSTRUCTION OF SEA-GOING SHIPS

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Developed by: V. Yerolayev, A. Bilokurets

Shipping Register of Ukraine
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