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FOR THE CLASSIFICATION, CONSTRUCTION AND EQUIPMENT OF MOBILE OFFSHORE DRILLING UNITS AND FIXED OFFSHORE PLATFORMS

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LIST OF CIRCULAR LETTERS AMENDING/SUPPLEMENTING NORMATIVE DOCUMENT

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Mobile Offshore Drilling Units and Fixed Offshore Platforms, 2006
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Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms of Russian Maritime Register of Shipping have been approved in accordance with the established approval procedure and come into force since the date of publication.

The Rules set down specific requirements for MODU and FOP, consider the recommendations of the IMO Code for the Construction and Equipment of MODU, as adopted by the IMO Assembly on 19 October 1989 (Resolution A.649 (16).

The unified requirements, interpretations and recommendations of the International Association of Classification Societies and the relevant resolutions of the International Maritime Organization have been taken into consideration in the Rules.

The present edition of the Rules is based on Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms (2001) taking into account additions and amendments of Notices No. 1 (2002), No. 2 (2003) and No. 3 (2004), as well as those developed immediately before the publication.

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CONTENTS

CLASSIFICATION AND CONSTRUCTION OF MODU/FOP

PART IV. STABILITY

PART V. SUBDIVISION

PART VI. FIRE PROTECTION

PART VII. MACHINERY INSTALLATIONS AND MACHINERY

PART VIII. SYSTEMS AND PIPING

PART IX. BOILERS, HEAT EXCHANGERS AND PRESSURE VESSELS

PART X. ELECTRICAL EQUIPMENT

PART XIV. AUTOMATION

PART XV. MODU AND FOP SAFETY ASSESSMENT

EQUIPMENT OF MODU AND FOP

PART IV. NAVIGATIONAL EQUIPMENT

PART V. EQUIPMENT FOR PREVENTION OF POLLUTION

CLASSIFICATION AND CONSTRUCTION OF MOBILE OFFSHORE DRILLING UNITS (MODU) AND FIXED OFFSHORE PLATFORMS (FOP)

PART I. CLASSIFICATION

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms[1] cover all self-propelled and non-self-propelled floating units, drilling ships, as well as floating offshore platforms of steel, iron concrete and composite materials, including the ice resistant type, which are held to the bottom by gravity, with piles or in a combined way and which are designed for the exploration/extraction of natural resources under the seabed and for other activities.

1.1.2 Technical requirements apply to all machinery, devices, apparatuses and equipment installed aboard MODU and FOP, whose normal operating conditions ensure the required safety of the unit as a whole in all modes of operation.

1.1.3 The drilling and production equipment (for recovery, refinement and transporting the products from the wells), as well as technological solutions connected with the safety of drilling and well operation, are to be in conformity with the requirements of state bodies engaged in safety supervision in the oil and gas industry.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 For the purpose of MODU/FOP Rules, the following definitions have been adopted.

Mobile offshore drilling unit (MODU) is a ship capable of drilling operations and/or resources extraction from under the seabed, such as oil, gas, sulphur or salt.

Surface unit (SU) is a unit with a MODU-, drilling ship- or barge-type displacement hull not intended for exploration/production of underground seabed resources.

Drilling ship is a ship with a drilling unit.

Self-elevating unit is a unit which, in operating conditions, is capable of raising its hull above the surface of the sea on legs resting on the seabed.

Column-stabilized unit is a floating drilling unit in which the displacement of columns spaced widely apart is used to ensure bouyancy and stability in all modes of operation (see definition "mode of operation", including submersion and emersion. The lower column sections may include underwater hulls and footings to ensure additional bouyancy or surface sufficient for the unit to remain supported by the seabed. To interconnect the columns, underwater hulls and footings, and to support the platform, bracing members having tubular cross section or truss-type structure can be used. Column-stabilized units are to be so designed as to effect drilling operations both afloat and supported by the seabed.

Submersible unit is a column-stabilized unit supported by the seabed in operating condition.

Semi-submersible unit is a column-stabilized unit which is afloat when in operating condition and which is kept in the horizontal plane by means of anchors, thrusters or other positioning equipment.

Tension leg unit is a unit having considerable surplus buoyancy under operating conditions, which is kept above the drilling location/recovery site with stretched anchor ties fixed on the seabed.

Fixed offshore platform (FOP) is an offshore oil and gas field structure consisting of an upper hull and a supporting foundation, which is fixed on the seabed throughout its use and which forms a part of the offshore oil and gas field construction.

FOP supporting foundation is a part of a FOP consisting of one or several supporting members on top of which the upper hull of the FOP is assembled.

Stability block is a watertight structure ensuring the buoyancy and stability of the construction, carriage of the upper hull and resistance to external influence when located on the seabed. It may consist of modules, supermodules, pontoons, columns, trusses and pile foundations.

Upper deck is a watertight structure upon which the upper hull is located and from which the freeboard is measured.

Supporting deck or supporting girders are structures on which the upper hull is assembled.

[1] Hereinafter referred to as "MODU/FOP Rules".

Upper hull consists of superstructures, deckhouses and other similar structures used for accommodating personnel, equipment, systems and devices which ensure the structure operation in accordance with the purpose. An upper hull is generally formed from module blocks.

Module block is a functionally complete section of the upper hull, e.g. energy, accommodation, production, etc. module blocks.

Module is a structure, generally one of the supporting block and/or deck, which is a transportable unit in itself.

Supermodule consists of two or more modules joined together and thus forming a transportable unit.

Transportable unit is a structure or section thereof which is transported on inland waterways and/or on sea.

Underwater pontoon is a flat-bottomed watertight structure with vertical sides.

Leg is a watertight, partially tight or vertical truss structure which takes up external loads and the weight of superimposed structures and equipment.

Buoyancy/stability pontoon is a watertight structure not forming part of the construction, which is temporarily fitted on it or on its module/supermodule to ensure buoyancy and/or stability.

Embarkation pad is a FOP component attached to the supporting foundation and used for embarkation and ship mooring.

Helicopter support facility is a MODU/FOP component used for helicopter landing and maintenance.

Drilling area is the area of a MODU/FOP in which equipment for the drilling of wells is installed.

Production area is the area of a FOP in which equipment for the recovery of products from the wells, refinement and transportation from the FOP is installed.

Accommodation area is the area of a FOP used for attendants accommodation.

Auxiliary equipment area is the area of a FOP in which auxiliary equipment is installed which is not directly associated with drilling and well operation and not intended for that purpose.

Ice resistant FOP is a FOP capable of taking up ice loads.

Gravity FOP (gravity fixed offshore platform) is a construction whose stability on the seabed is mainly ensured due to its deadweight and the weight of ballast taken in.

Pile FOP (pile — supported fixed offshore platform) is a construction whose stability on the seabed is mainly ensured due to piles driven in the seabed.

Mast FOP is a deep-water fixed offshore platform whose stability is ensured either by guys or by a relevant volume of flotation.

Deep-water leg platform is a platform on legs whose height is appreciably greater than their typical cross section. It consists of the following components: legs (one at least), lower supporting foundation coming in contact with the bottom, and the upper bearing structure.

Shallow-water leg platform is a platform on legs whose height is comparable to their typical cross section. They consist of the same components as deep-water leg platforms.

Artificial island (caisson) is a shallow-water platform on a solid metal foundation.

Monopod/monocone is a single-support shallow-water platform of the tower type with vertical or inclined walls respectively.

Sea depth is a vertical distance measured from the seabed to the average water level plus the total height of the astronomical and storm tides.

Clearance is a vertical distance measured from the average level of calm water plus the total height of the astronomical and storm tides to the lower section of the supporting deck or the upper structure of the platform.

Mode of operation is a condition in which a MODU/FOP may operate or function while being above the drilling location/recovery site or the condition during any way of its transportation to such a location or site. When in a mode of operation, a MODU/FOP may be in one of the following conditions:

operating condition is a condition wherein a MODU/FOP is on location for the purpose of conducting drilling or other similar operations, and combined environmental and operational loadings are within appropriate design limits established for such operations;

severe storm condition is a condition wherein a MODU may be subjected to the severest environmental loading for which it is designed. Drilling operations are assumed to be discontinued;

transit condition is a condition wherein a MODU/FOP is moving from one geographical location to another.

Ships participating in the operations at sea are as follows:

carrier is any ship directly involved in the carriage of the construction or its sections, a barge for instance, where the construction or its sections are floatable, this term will mean the floating structure proper;

transport is any ship used to create propulsive power for conveying the construction or its sections, for instance, a pulling or pushing tug, icebreaker, tanker, etc;

transport system is the carrier(s) and transport(s) operating as a system, for instance, a tug with a towline together with the construction.

Additional requirements are those not contained in the MODU/FOP Rules, which are put forward by Russian Maritime Register of Shipping[1] during its classification activities.

2 CLASS OF MODU/FOP

2.1 GENERAL

2.1.1 MODU/FOP are covered by the requirements of 2.1, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships.

2.2 CLASS NOTATION

2.2.1 The class notation assigned to a MODU/FOP by the Register consists of the character of classification and additional distinguishing marks and descriptive notations describing the design and purpose of the ship or floating facility.

2.2.2 The character of classification assigned to a MODU/FOP by the Register comprises distinguishing marks as follows:

KM⍟, **KM**★, **(KM)**★ for self-propelled MODU:

KE⍟, **KE**★, **(KE)**★ for non-self-propelled MODU and FOP with a total power output of prime movers above 100 kW.

2.2.3 Depending on the classification body under whose supervision and according to whose Rules the ship or floating facility is built, the character of classification is established in the following way:

.1 MODU/FOP built according to the Rules and under the supervision of the Register receive a class notation with the character of classification **KM**⍟ or **KE**⍟;

.2 MODU/FOP which as a whole (or their hull, machinery installation, machinery, equipment) are built and/or manufactured according to the Rules and under the supervision of another classification body recognized by the Register and which are classed with the Register will receive a class notation with the character of classification **KM**★ or **KE**★ ;

.3 MODU/FOP which as a whole (or their hull, machinery installation, machinery, equipment) are built and/or manufactured without the supervision of a classification body recognized by the Register or without the supervision of any classification body at all, and which are classed with the Register, will receive a class notation with the character of classification **(KM)**★ or **(KE)**★.

2.3 SUBDIVISION MARKS

2.3.1 The subdivision of a MODU is considered satisfactory, if the requirements of Part V "Subdivision" of MODU/FOP Rules are complied with in respect of the trim and stability of damaged MODU with one of its compartments flooded and the damage being as stated in 3.2. In this case, no subdivision mark is added to the class notation.

2.3.2 At owner's request, a MODU may receive one of the following marks in its class notation: [1] or [2] in which case the MODU is also to comply with the requirements of Part V "Subdivision" of the Rules for the Classification and Construction of Sea-Going Ships.

2.4 AUTOMATION MARK

2.4.1 If the automation equipment of the main machinery and/or electrical power plant of MODU or FOP comply with the requirements of Part XIV "Automation" of MODU/FOP Rules, one of the following automation marks are to be added to the MODU/FOP character of classification depending of the extent of automated functions and features of automation facilities, namely:

.1 A1 — the extent of automation functions is ensured by traditional facilities and is sufficient for

[1] Hereinafter referred to as "the Register".

operation of machinery (propulsion) and/or electrical power plant with unattended machinery spaces and main machinery control room;

.2 A2 — the extent of automation functions is ensured by traditional facilities and is sufficient for operation of machinery (propulsion) and/or electrical power plant with one operator in the engine room and with unattended machinery spaces;

.3 A1K or **A2K** — automated functions as specified for automation marks **A1** or **A2**, respectively, are implemented with the use of computers or programmable logical controllers complying with the requirements of Section 5, Part XIV "Automation" of MODU/FOP Rules;

.4 A1И, **A2И** — automated functions, as specified for automation marks **A1** or **A2**, respectively, are implemented with the use of integrated computer-based control and monitoring system complying with the relevant requirements of Section 5, Part XIV "Automation" of MODU/FOP Rules. Along with that, the electronic information provided to the operating personnel and control functions at control stations are implemented with the use of the common redundant information network.

2.5 DESIGNATION FOR PARTICULAR TYPES AND PURPOSES OF MODU/FOP

2.5.1 If the design of a MODU/FOP is basically the same as one of those defined under 1.2 and if it complies with the relevant requirements of MODU/FOP Rules, one of the following descriptive notations will be added to the class notation proceeding from the MODU design:

self-elevating MODU;
semi-submersible MODU;
submersible MODU;
tension leg MODU;
drilling ship;
drilling barge;
gravity FOP;
pile FOP;
mast FOP.

The "ice-resistant" descriptive notation may be added to the above descriptive notations.

2.5.2 Where the design of a MODU/FOP is principally different from those defined under 1.2, the definition of its type and of the descriptive notation to be added to the class notation is subject to special consideration by the Register in each case.

2.6 DESIGNATION OF THE OPERATING AREA AND CONDITIONS

2.6.1 If a MODU/FOP is designed to operate in a particular area and the maximum loads due to wind, sea, ice and tide are considered for this area, the area, loads and ice strengthening are to be mentioned in the Classification Certificate.

3 SURVEY PROCEDURE AND SCOPE

3.1 TYPES AND PERIODICITY OF SURVEYS

3.1.1 The following types of initial surveys of MODU/FOP are performed by the Register:

surveys which are carried out during construction of MODU/FOP under the Register supervision;

surveys of MODU/FOP built under the supervision of other classification society or any other competent body.

3.1.2 Periodical surveys.

3.1.2.1 Special surveys are carried out to reinstate class after each 5 years of MODU/FOP operation. Requirements of 3.3, Part I "General Provisions" of the Rules for the Classification Surveys of Ships apply to commencement, preparation and performance of MODU special surveys in full. The Register, designer and shipowner develop at the design and construction stage the Survey Program describing all actions in respect of FOP or its elements survey during the planned service life of FOP, submersible units. The program is to include the following main parts:

general description of a survey with references to respective Parts of the Rules;

duration and methods of surveys;

time and periodicity of surveys;

procedures for messaging, data collection and registration;

assessment procedures for the registered messages;

modernization procedures.

3.1.2.2 Annual surveys are carried out each calendar year within 3 months before or after the annual survey anniversary date.

3.1.2.3 The MODU dry-dock surveys are to be carried out during special surveys. Besides, it might be required after casualty and in special cases as the occasional survey.

Survey of the underwater part of FOP, submersible units is to be carried out once in 10 years after completion of drilling activity and it is a part of the Survey Program; it is carried out by means of the diving equipment and instrumentation for assessment of technical condition of hull, pile foundation, reinforced concrete structures etc. Possibility of FOP operation after the 25 year anniversary is agreed in each case among the Register, designer and shipowner.

3.1.2.4 Intermediate surveys are carried out instead of the second or third annual survey upon the shipowner's request.

3.1.2.5 Upon the shipowner's request the Register schedules a continuous survey system for MODU/FOP. Requirements of 3.7, Part I "General Provisions" of the Rules for the Classification Surveys of Ships are applicable in respect of performance of continuous survey.

3.1.3 Occasional surveys.

Occasional surveys of MODU/FOP or their elements are carried out in all cases except initial and periodical surveys. Occasional surveys are carried out to control detected deficiencies or damages after casualty including liquidation of consequences of oil guishing or drilling equipment sticking as well as in other cases described in 3.8, Part I "General Provisions" of the Rules for the Classification Surveys of Ships applicable to MODU/FOP.

3.1.4 Specific surveys.

Survey during marine operations is to be referred to specific surveys of MODU/FOP. The reason for this is that MODU/FOP may be fully or partially (assembly modules) constructed thousands of miles away from further area of navigation. The process of transportation of MODU/FOP or their elements to the site, transition or move to a new place of operation, determination of safe conditions for these operations with justification of permissible risk is set forth in Part XVI "Marine Operations" of MODU/FOP Rules. Special programs of survey reflecting the following issues are to be carried out and agreed by designer, constructor, shipowner with the classification society for the marine operations:

assembly of the drilling unit afloat at the shipyard;

preparation of the site;

shipping of separate elements or drilling unit bodily to the site;

installation of unit in the site;

removal from the site;

field move (or transit) to a new area of operation (within or beyond assigned area of navigation).

3.2 INITIAL SURVEYS AND SURVEYS DURING CONSTRUCTION

3.2.1 MODU/FOP constructed without supervision of the Register or other body empowered by the Register for substitution or those holding a class of other classification society or other competent organisation are to be submitted to the initial survey to accept MODU/FOP under the Register supervision. MODU/FOP which used to have the Register class but lost it for various reasons should be also submitted for the initial survey.

3.2.2 The initial survey of MODU/FOP includes a detailed examination, checks, tests and measurements which scope depends on age of MODU/FOP, their technical condition, availability of technical documentation and documents of recognised competent bodies for supervision. The scope of initial survey is equal to the scope of the special survey according to the age of the object including dry-dock survey. Data on technical condition of underwater part based on the instrumental methods of assessing underwater structural wear, in the area of alternating waterline and in the ice wear area are to be submitted for FOP. Data for assessment of effectiveness of protection, results of diving survey of underwater part are to be submitted.

3.2.3 If the Classification Certificate of the recognised classification body is available, the scope of the initial survey may be reduced to the scope of the intermediate survey while the term of the next special survey is fixed in accordance with the validity of the existing Classification Certificate.

The validity of the periodical surveys is assigned keeping due note of the validity of the Classification Certificate of the other classification society.

3.2.4 Compliance of hull, ship arrangements, equipment and outfit, machinery installations and systems, electrical equipment with the requirements of MODU/FOP Rules is to be checked during initial survey of MODU/FOP.

3.2.5 Compliance of MODU/FOP hull with the requirements of Part II "Hull" of MODU/FOP Rules in respect of materials, welding and strength depending on the area of navigation and all operating conditions specified in the Operating Instruction for MODU/FOP is to be checked during the initial survey.

During technical survey of hull wear of structural elements, damages, quality of welds and impermeability is to be checked.

3.2.6 Owners of MODU/FOP are to submit technical documentation to the Register in the scope required to check execution of requirements of Part II "Hull" of MODU/FOP Rules as well as documents issued by classification and other competent supervision bodies, manufacturer certificates etc. during initial survey.

The list of technical documentation is submitted by MODU/FOP owner to the Register during initial survey.

3.2.7 Assessment of structural strength of the MODU hull is performed:

drilling ships — comparison of the member scantlings required by Part II "Hull" of MODU/FOP Rules with scantlings given in drawings keeping due note of provisioning of strength of members from forces arising due to drilling, anchoring and other operations. If necessary, a comparative report for transverse section modulus of the drilling ship and square of the transverse section of the upper deck may be required;

self-elevating, semi-submersible and submersible MODU/FOP — check of compliance of the strength calculations for MODU/FOP hull structures with the requirements of Part II "Hull" of MODU/FOP Rules.

If a unit is classed by the recognised classification society assessment of strength may be reduced to random check of some main members of the MODU hull keeping due note of similarity of the Rules of that classification society and Rules of the Register.

If significant wear has been detected upon results of survey, the Surveyor is to demand measurements of residual thicknesses of the MODU hull structural elements for comparison of permissible wear.

3.2.8 Composition of ship arrangements, equipment and outfit, their completeness of set, construction, arrangement and installation as well as regulated characteristics (power, effectiveness, speed etc.) are to be checked for compliance with the requirements of MODU/FOP Rules during the initial survey of MODU/FOP.

3.2.9 Arrangements, equipment and outfit of the drilling ships is to fully comply with the requirements of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships and special requirements of MODU/FOP Rules.

3.2.10 Performance of the requirements of the Rules for the Classification and Construction of Sea-Going Ships and requirements of MODU/FOP Rules, as well as due technical condition of closures, steering gear, anchor, mooring and towing arrangement, arrangements for raising and submersion of hull of the self-elevating units, arrangements for raising and submersion of submersible sea-water pump, crew protective means, MODU/FOP spaces and emergency outfit are to be checked during initial survey. Performance of the requirements in respect of construction of masts and standing rigging and their strength is to be checked.

3.2.11 Ensuring resistance to flooding in all operational conditions afloat is to be checked during initial survey based on results of calculations in accordance with the requirements of Part V "Subdivision" of MODU/FOP Rules.

3.2.12 Information on Damage Trim and Stability is to reflect all states of MODU required by Part V "Subdivision" of MODU/FOP Rules.

3.2.13 Strength calculations of MODU hull structural elements in working condition are to be submitted during initial survey of self-elevating and submersible units.

3.2.14 For the purposes of fire protection of MODU/FOP performance of the requirements of MODU/FOP Rules in respect of purpose of these objects is checked during initial survey keeping due note of their structure and dimensions in respect of:

arrangement and equipment of spaces, fire extinguishing station and fire control station;

ensuring safe evacuation of people from accommodation and service spaces;

subdivision of accommodation spaces (accommodation modules) into main fire vertical zones and protection of spaces within fire zones;

application of respective fire-resistant and fire-retarding structures and closures in them;

installation of self-closing fire doors, their remote control and automation systems;

closures of spaces with excessive air pressure;

closures of doors, shafts, air ducts, funnel annuluses, skylights and other openings in engine and pump rooms and their drives, as well as panelling and lining of ceilings;

mandatory provisioning of active means for fire fighting;

technical characteristics and layout of machinery of systems, materials and construction of pipelines, their joints and fittings, pipe laying and securing;

for MODU/FOP operating at subzero temperatures, insulation or other means assuring non-freezing of fire mains on open decks;

drives of remote operation of system valves and machinery;

water intake from submersible pumps of sea water;

complete set of fire-fighting outfit, spares and tools;

fire detection systems and fire warning alarms;

instrumentation;

presence of control station plans, subdivision plan, plans of fire extinguishing systems and fire detection and alarm systems, means of access to compartment and evacuation posted in the Main Fire Control Station, wheelhouse and on the open place in the corridor and in hall;

availability of certificates and/or results of analysis of the used fire extinguishing mediums (foam generators and other mediums) and their quantity as per design calculations.

3.2.15 During initial survey of machinery installations and machinery as well as boilers, heat exchangers and pressure vessels, the following recommendations are to be observed.

3.2.15.1 During initial survey of machinery installations, boilers, heat exchangers and pressure vessels of MODU/FOP the scope of survey and conditions of its performance are determined in accordance with requirements of 1.3.4, 1.3.5, Part II "Survey Procedure and Scope" of the Rules for the Classification Surveys of Ships.

The following items refer to the section concerning auxiliary machinery:

sea water submersible pumps,

jacking mechanisms of self-elevating unit,

arrangements for raising (submersion) of sea water submersible pumps,

fans for enclosed spaces with excessive air pressure.

3.2.15.2 Heat exchangers for the drilling equipment are liable to the Register supervision during initial survey. Supervising system adopted by the competent bodies which is defined by the owner may be used for the periodical surveys of these apparatuses.

Air collectors, air receivers constituting a part of the drilling equipment are to be submitted to the Register survey also after major repair or replacement.

3.2.16 During initial survey of the automated and automatic control systems the following is to be assured.

3.2.16.1 During initial survey of the MODU/FOP automated and automatic control systems provisions of 1.3.6, Part II "Survey Procedure and Scope" of the Rules for the Classification Surveys are applied in full.

3.2.16.2 The following items are to be checked on all MODU without regard whether an automation distinguishing mark is available:

MODU mooring positioning system;

MODU hull remote jacking system,

remote control system for ballast pumps and valves of the draining system (except for self-elevating units),

protection and alarm system (control of the MODU hull in the operating position, air control and ventilation of enclosed spaces with excessive air pressure).

3.2.17 The following actions are to be taken during initial survey of systems and pipelines.

3.2.17.1 During initial survey of MODU/FOP the compliance of the composition of systems and pipelines as well as systems and pipelines of the machinery installation with fittings and instrumentation, their construction, arrangement and installation with the requirements of MODU/FOP Rules is to be checked. Technical condition of systems and pipelines is to be checked during this survey.

3.2.17.2 All requirements of 3.2.17.1 refer also to:

the hydraulic drives of the MODU hull jacking machinery;

the hydraulic drives of the raising and submersion of columns for the sea water submersible pumps;

self-elevating unit sea water feeding system;

mud manifold, cement grout manifold and pneumatic transport system for the powdered materials;

ventilation system of enclosed spaces with excessive air pressure.

3.2.18 The following actions are to be taken during initial survey of electrical equipment.

3.2.18.1 Compliance of the MODU/FOP electrical equipment, its structure, arrangement, installation, technical characteristics with the requirements of MODU/FOP Rules is to be checked during initial survey and technical condition of the equipment is to be assessed.

3.2.18.2 Electrical drilling equipment is not liable to the Register supervision except for:

explosion-proof electrical equipment located in dangerous rooms and spaces;

connected cables;

safety, insulation and earthing arrangements.

However, the Register is to put forward applicable requirements for any electrical equipment if it has been detected during survey that operation or technical condition of this electrical equipment may affect normal operation or lead to failure of the standard electrical equipment as well as to endanger human life or cause fire or explosion.

3.2.19 Surveys carried out during construction of MODU/FOP.

3.2.19.1 During construction MODU/FOP is to be subjected to survey in the scope prescribed by MODU/FOP Rules and Guidelines for Technical Supervision during Construction of MODU/FOP and Manufacture of Products by Technical Projects and Working Documentation.

3.2.19.2 The date of MODU/FOP survey upon completion of construction is the date of actual completion of survey and issue of MODU/FOP Classification Certificate and ship's documents.

During initial survey the registered number is assigned to MODU/FOP and Seaworthiness Certificate for use with the flag of the Russian Federation is issued.

3.3 PERIODICAL SURVEYS

3.3.1 The scope of periodical surveys and intervals between them are to correspond to those specified in Table 3.3 to the extent as far as it is applicable to the given MODU/FOP. Survey of objects of drilling ships and elements of MODU/FOP similar to ship objects is to be carried out in the scope and in time specified in Table 2.1.1, Part II "Survey Procedure and Scope" of the Rules for the Classification Surveys of Ships.

3.4 ANNUAL SURVEYS

3.4.1 Hull.

3.4.1.1 The summarised scope of surveys of structural elements of MODU hull, drilling ships and FOP during annual survey is set forth in table 2.1.1, Part II "Survey Procedure and Scope" of the Rules for the Classification Surveys of Ships and Table 3.3 of MODU/FOP Rules.

During this type of survey drilling and cement pump rooms, chemical agent tanks for drilling and cement grout, tanks for oil collection during trial drilling of wells, rooms for drilling agent cleaning systems and compressor station are liable to mandatory survey from inside.

Ballast tanks are to be subjected to internal survey on an annual basis after the second special survey if the tank protective coatings have not been applied since construction as well as if there is no protective coating in tanks.

If ballast tanks are covered by protective coating or cathodic protection they are to be surveyed from inside at each second annual survey after the second special one.

At each third annual survey tanks (compartments) for storage of drilling agent and holes for legs, columns of submersible sea water pump and drilling instrument with strengthenings are liable to examination from inside.

Other structures of the MODU hull, drilling ships and FOP are liable to examination (C) only from outside. Examination from inside is carried out upon discretion of the Register Surveyor, if necessary.

3.4.1.2 Examination (C) of the self-elevating units' legs and stability columns with bracings of semi-submersible and submersible units is carried out during each second annual survey which is combined with the survey of underwater part of MODU hull. During this survey, strips and welds between strips and legs are to be examined very thoroughly, as well as welds of bracings in their junction with stability columns.

3.4.1.3 During survey of the MODU underwater part which is combined with the annual survey external examination of structures and unit underwater part is to be carried out. Structural elements of legs, pontoon plating in the place of examination, plating of tanks of legs, well walls for legs, plating of stability columns with bracings, cathodic protection are to be cleaned from mud, rust and old buckling paint to carry out survey.

3.4.1.4 The self-elevating unit is to be risen on the legs above water to enable free access to underwater structures during the underwater survey. Underwater part of the legs is to be surveyed by means of the modern technical means: underwater TV, underwater photography, special equipment and instruments.

Underwater survey of semi-submersible, submersible units and FOP is carried out by means of the state-of-the-art technical means listed above.

Underwater survey of the drilling ships is carried out in accordance with respective requirements of 3.2 and Table 2.1.1, Part II "Survey Procedure and Scope" of the Rules for the Classification Surveys of Ships.

3.4.2 Equipment, arrangements and outfit.

3.4.2.1 Provisions of Table 2.1.1, Part II "Survey Procedure and Scope" of the Rules for the Classification Surveys of Ships as regards periodicity of annual surveys fully apply to hull closures in the MODU/FOP and drilling ships: scuttles and hatch covers on open decks, watertight outer doors, side scuttles, companion hatches, skylights, ventilation hatches, covers of vent ducts.

Table 3.3

SCOPE OF PERIODICAL SURVEYS

Symbols:

O — examination with provision of access, opening up and dismantling where necessary;

C — external examination;

M — measurement of wear, clearances, isolation resistance etc;

H — pressure testing (hydraulic, pneumatic);

P — operation testing of machinery, equipment and arrangement, their external examination;

E — verification of availability of current documents and/or brands to confirm testing of instruments by appropriate competent bodies, if they are subject thereto.

Nos.	Item to be surveyed	Survey														
		1 st annual	2 nd annual	3 rd annual	4 th annual	1 st special	1 st annual	2 nd annual	3 rd annual	4 th annual	2 nd special	1 st annual	2 nd annual	3 rd annual	4 th annual	3 rd special
1	**Hull**[1]															
1.1	Underwater structural members of MODU, submersible units and FOP [2] (external examination):															
.1	legs[3]			C		O			C[4]		O			C[4]		OM[5]
.2	stability columns with bracings			C		O			C[4]		O			C[4]		OM[5]
.3	footings and tanks of legs			C		O			C[4]		O			C[4]		OM[5]
.4	columns of submersible sea water pumps	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]
.5	underwater structures of submersible units and FOP[2]			C		O			C[4]		O			C[4]		OM[5]
.6	area of alternating waterlines and ice loads structures of submersible units and FOP[2]			C		O			C[4]		O			C[4]		OM[5]
1.2	Above-water structural members of MODU, submersible unit and FOP [2] (external examination):															
.1	legs			C		O			C		O			C		O
.2	stability columns with bracings			C		O			C		O			C		OM[5]

Table 3.3 - continued

Nos.	Item to be surveyed	Survey														
		1 st annual	2 nd annual	3 rd annual	4 th annual	1 st special	1 st annual	2 nd annual	3 rd annual	4 th annual	2 nd special	1 st annual	2 nd annual	3 rd annual	4 th annual	3 rd special
.3	structure of submersible MODU, FOP[2] in the area of mooring operations of service ships and supply ships	C	C	C	C	O	C	C	C	C	O	C	C	C	C	O
.4	columns of submersible sea water pumps	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]
.5	drilling floors of submersible and semi-submersible units, FOP[2] (plating and framing)	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]
.6	jack houses	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]
.7	holes for legs					O					O					OM[5]
.8	stiffeners and plating of blow-out preventer area (spider deck) and its attachment to hull of MODU, FOP[2]	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]
.9	skids for moving substructure for drilling derrick					O					O					OM[5]
.10	helicopter deck and its attachment to unit's hull	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]
.11	foundations of drilling equipment and winches of tensioners for lines and marine riser	C	C	C	C	O	C	C	C	C	O	C	C	C	C	O
.12	foundations of equipment for underwater engineering works	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]
.13	foundations of arrangements for raising and submersion of columns of submersible sea water pumps	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]
1.3	Underwater and above-water structural members of MODU and FOP (internal examination of separate members or unit's hull):															
.1	legs					O					O					OM[5]
.2	tanks of legs					O					O					OM[5]
.3	stability columns, compartments and tanks of stability columns			C		O			C		O			C		OM[5]
.4	holes for legs, columns of submersible sea water pumps and drilling tools with associated reinforcements			C		O			C		O			C		OM[5]
.5	reinforcements of foundation of drilling equipment and winches of tensioners for lines and marine riser			C		O			C		O			C		OM[5]

Table 3.3 - continued

Nos.	Item to be surveyed	Survey														
		1 st annual	2 nd annual	3 rd annual	4 th annual	1 st special	1 st annual	2 nd annual	3 rd annual	4 th annual	2 nd special	1 st annual	2 nd annual	3 rd annual	4 th annual	3 rd special
.6	reinforcements of foundation of equipment for underwater engineering works			C		O			C		O			C		OM[5]
.7	reinforcements of foundations of arrangements for raising and submersion of columns of submersible sea water pumps			C		O			C		O			C		OM[5]
.8	tanks (compartments) for drilling mud [6]			C		OH			C		OH			C		OM[5]H
.9	chemical reagent tanks for drilling mud and cement grout [6]			C		OH			C		OH			C		OM[5]H
.10	tanks for oil reception when testing a well	C	C	C	C	OH	C	C	C	C	OH	C	C	C	C	OM[5]H
.11	tanks for oil reception					OH					OH					OM[5]H
.12	spaces for drilling and cement pumps	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]
.13	room for drilling mud cleaning system	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]H
.14	compressor room	C	C	C	C	O	C	C	C	C	O	C	C	C	C	OM[5]H
2	**Equipment, arrangements and outfit**															
2.1	Closing appliances of openings:															
.1	tanks of legs					OH					OH					OM[5]H
.2	ballast tanks of submersible and semi-submersible units, self-elevating units, FOP					OH					OH					OM[5]H
.3	for well cementing					OH					OH					OM[5]H
.4	for passage of cathodic protection cables					OH					OH					OH
.5	for inspection of submersible sea water pumps					OH					OH					OH
2.2	Anchor positioning system, MODU dynamic positioning system	C	C	C	C	OP	C	C	C	C	OP	C	C	C	C	OP
2.3	Jacking system of self-elevating unit	C	C	C	C	OP	C	C	C	C	OP	C	C	C	C	OP
2.4	Fixing arrangements of self-elevating unit	C	C	C	C	OP	C	C	C	C	OP	C	C	C	C	OP
2.5	Arrangements for raising and submersion of submersible sea water pumps	C	C	C	C	OP	C	C	C	C	OP	C	C	C	C	OP

3	**Fire protection**															
3.1	Enclosed spaces maintained in overpressure and closures of openings therein	C	C	C	C	OPH	C	C	C	C	OPH	C	C	C	C	OPH
3.2	System of water intake from sea water supply system of MODU/FOP	P	P	P	P	OP	P	P	P	P	OP	P	P	P	P	OP
3.3	Gas detection and alarm system	P	P	P	P	OP	P	P	P	P	OPH	P	P	P	P	OP
3.4	Heliport equipment	C	C	C	C	O	C	C	C	C	O	C	C	C	C	O
3.5	Drawings and diagrams	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
4	**Machinery installation**															
4.1	Submersible sea water pumps	P	P	P	P	OP	P	P	P	P	OP	P	P	P	P	OPH
4.2	Jacking system of self-elevating unit	P[7]	P[7]	P[7]	P[7]	OP	P[7]	P[7]	P[7]	P[7]	OP	P[7]	P[7]	P[7]	P[7]	OP
4.3	Arrangements for raising and submersion of columns of submersible sea water pumps	P	P	P	P	OP	P	P	P	P	OP	P	P	P	P	OP
5	**Pressure vessels**															
5.1	Pressure vessels for marine risers and heave compensation systems and their fittings	P	P	P	P	OP[8]	P	P	P	P	OP	P	P	P	P	OP[8]
5.2	Safety valves	P	P	P	P	OPH	P	P	P	P	OPH	P	P	P	P	OPH
6	**Automation**															
6.1	Systems (including alarm and protection):															
.1	position measurement systems of self-elevating units on legs	P	P	P	P	OP	P	P	P	P	OP	P	P	P	P	OP
.2	automatic and remote control systems of jacking arrangements of self-elevating units	P[7]	P[7]	P[7]	P[7]	OP	P[7]	P[7]	P[7]	P[7]	OP	P[7]	P[7]	P[7]	P[7]	OHP
.3	automated (automatic) control systems of valves and arrangements of ballast system	P	P	P	P	OP	P	P	P	P	OP	P	P	P	P	OP
7	**Systems and piping**															
7.1	ydraulic drive system of jacking arrangements of self-elevating units	P	P	P	P	OP	P	P	P	P	OP	P	P	P	P	OP

Table 3.3 - continued

Nos.	Item to be surveyed	Survey														
		1 st annual	2 nd annual	3 rd annual	4 th annual	1 st special	1 st annual	2 nd annual	3 rd annual	4 th annual	2 nd special	1 st annual	2 nd annual	3 rd annual	4 th annual	3 rd special
7.2	Hydraulic drive system of arrangements for raising and submersion of columns of submersible sea water pumps	P	P	P	P	OP	P	P	P	P	OP	P	P	P	P	OP
7.3	Sea water system of self-elevating unit	P	P	P	P	OP	P	P	P	P	OP	P	P	P	P	OP
7.4	Ventilation system of enclosed spaces maintained in overpressure	P	P	P	P	OP	P	P	P	P	OP	P	P	P	P	OP
7.5	Drilling mud emergency discharge system	O	O	O	O	OP	O	O	O	O	OP	O	O	O	O	OP
7.6	Ballast pumping system for the pontoons of submersible and semi-submersible units	P	P	P	P	OP	P	P	P	P	OP	P	P	P	P	OP
8	**Electrical equipment**															
8.1	Electric propulsion plants	P	P	P	P	OEMP	P	P	P	P	OEMP	P	P	P	P	OEMP
8.2	Electric drives of essential arrangements and machinery as well as their control, protective, starting and monitoring devices of:															
.1	jacking system of self-elevating unit	P[7]	P[7]	P[7]	P[7]	OMP	P[7]	P[7]	P[7]	P[7]	OMP	P[7]	P[7]	P[7]	P[7]	OMP
.2	arrangements for raising and submersion of sea water pipe and columns of submersible sea water pumps	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP
.3	submersible sea water pumps	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP
.4	emergency selective shutdown facilities for disconnection of consumers	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP
8.3	Cabling Protection of cables (additional) by watertight and fire bulkheads and decks	C	C	C	C	O	C	C	C	C	O	C	C	C	C	O
8.4	Signalling devices of:															
.1	gas detection and alarm[9]	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP

.2	control of limiting parameters of jacking system of self-elevating unit	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP
.3	position of remote-controlled valves of ballasting and drainage systems	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP
.4	level of liquid in tanks, bilges, etc.	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP
.5	control of air pressure of ventilation systems of enclosed spaces and equipment maintained in overpressure	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP
.6	failure of ventilation system in dangerous spaces	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP
.7	control of water level in sea water storage tank	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP
.8	control of position of unit	P	P	P	P	OMP	P	P	P	P	OMP	P	P	P	P	OMP

N o t e . During annual surveys measurements of insulation resistance of cabling and essential electric machinery and devices, cabling and electrical equipment in dangerous rooms and spaces are to be carried out. During special surveys measurements of the insulation resistance of all cabling and all stationary electric machinery and devices are to be carried out.

[1] Underwater survey of hull, screw rudder system of drilling ships is to be performed twice within 5 years. However, the interval between dry-docking surveys is not to exceed 36 months.

In justified cases survey of underwater part of self-elevating unit is allowed when hull is elevated on legs provided free access to structural elements above water is enabled and positive results of the diver's examination of legs under water are provided.

[2] Frequency of surveys of underwater part of fixed offshore platforms is stated in the Survey Program — see 3.1.2.1.

[3] Survey of lower parts of legs which usually are supported by seabed while the unit is in operation is to be carried out in dry- dock. In justified cases their survey is allowed when the unit is afloat.

[4] The scope of periodical surveys of underwater outer part of pontoons of semi-submersible, self-elevating and submersible units is scheduled for the intermediate survey. The intermediate survey may be carried out by means of diving survey. After the first and second special survey replacement of the intermediate survey by the diving survey is possible if ballast tanks are painted.

[5] Residual thickness measurements beginning from the third special survey are to be carried out during every special survey of a unit in the scope determined by the Surveyor depending on the technical condition.

[6] Only integral tanks are subject to the Register supervision.

[7] Readiness for operation, running order of safety, protection and interlocking devices, remote (automatic) control and alarm systems are checked during the annual survey. Check of the MODU raising (submersion) is not required.

[8] H — only for vessels which are not accessible to full internal examination.

[9] Check of availability of the document issued by a competent body confirming the specified characteristics of air inspection sensors during special survey.

3.4.2.2 During annual survey such specific closures for MODU are liable to external examination (C): openings for passage of cathodic protection cables, closures of scuttles for examination of submersible sea water pumps and closures of scuttles for extra water discharge from the sea water tank.

3.4.2.3 Steering gear of drilling ships and self-propelled MODU is liable to the annual survey in the scope set forth in Table 2.1.1 and 3.3.1, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships.

3.4.2.4 Anchor gear of MODU, FOP, drilling ships (including positioning system) is liable to the annual survey in the scope set forth in Table 2.1.1 and 3.3.2, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships and Table 3.3 of the present Part.

3.4.2.5 Towing arrangements of MODU/FOP, drilling ships are liable to the annual survey in the scope set forth in Table 2.1.1 and 3.3.3, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships.

3.4.2.6 Towing arrangement of MODU, drilling ships is liable to the annual survey in the scope set in Table 2.1.1 (2.5, 2.5.3, 2.5.4) and 3.3.4.1, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships. Towing hawser arrangement which is a part of the MODU towing arrangement is to be surveyed in operation annually.

3.4.2.7 Arrangement for jacking of self-elevating MODU is liable to the annual survey in assembled condition. Examination may be carried out both in transit and operating condition.

3.4.2.8 Arrangement for raising and submersion of submersible sea water pumps is liable to survey in assembled condition during annual survey of MODU. Meanwhile, one of the self-contained arrangements is to be submitted for survey in the uppermost position.

3.4.2.9 Protective means for the crew — catwalks and underdeck passages, deck rails on open decks and yards, bulwarks as well as ship spaces — control stations, accommodation and service spaces, spaces for mud pumps and cement pumps, corridors, passages, doors and stairs are liable to survey during annual survey of MODU, drilling ships and FOP.

3.4.2.10 Emergency outfit is liable to survey during annual survey of MODU, drilling ships and FOP.

3.4.3 Fire protection.

3.4.3.1 The scope and periodicity of surveys of fire protection objects during annual survey of MODU, drilling ships and FOP is determined in accordance with Section 3, Table 2.1.1, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships.

3.4.3.2 There are some specific MODU fire protection objects: enclosed spaces with excessive air pressure and their closures — they are liable to the annual survey by means of external examination (C); water scoop of submersible sea water pumps is to be checked in operation during the annual survey; air control system is to be checked in operation during annual survey; heliport equipment is to be checked by means of external examination.

3.4.4 Machinery installations.

3.4.4.1 The summarized scope of surveys of the MODU machinery installations, drilling ships and FOP during annual survey is set forth in Table 2.1.1, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships and Table 3.3 of the present Part.

3.4.4.2 During check of main engines in operation during annual survey of MODU and drilling ships, fitness of engines for operation, running order of manoeuvring and starting devices, remote control devices, hanging or drive machinery are to be verified. In such case putting of the main engines into operating mode (revolutions, load and other parametres) may be omitted.

3.4.4.3 The scope of survey of shafting and propeller during annual survey is set forth in Table 2.1.1, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships.

3.4.4.4 The following machinery is referred to the auxiliary machinery of MODU, drilling ships and FOP: submersible sea water pumps, MODU jacking system, arrangements for raising/submersion of columns of submersible sea water pumps, fans for enclosed spaces maintained in overpressure.

The scope of annual surveys of the above auxiliary machinery is set forth in Table 3.3 of the present Part.

3.4.4.4.1 During annual survey of the MODU jacking system machinery, pumps of variable capacity as well as limit circuit breakers are to be checked manually. Readiness for operation and running order of safety, protective and interlocking devices, remote (automated) control and alarm systems is to be checked also.

3.4.4.4.2 During annual survey of arrangements for raising and submersion of columns of sea water submersible pumps, it is allowed to test them in operation without load, i.e. without raising and submersion of columns. Operability of limit circuit breakers is checked manually.

3.4.4.5 The summary of the scope of the annual surveys of boilers, heat exchangers and pressure vessels is set forth in Table 2.1.1, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships and Table 3.3 of the present Part.

3.4.4.6 The scope of survey of the automated and automatic control systems during annual survey of MODU, drilling ships and fixed offshore platforms is set forth in Table 2.1.1, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships and Table 3.3 of the present Part.

3.4.4.6.1 During annual survey of the automation equipment the following items are to be checked:

remote (automated) control system for the MODU jacking system by means of simulation which is carried out in accordance with the operating instruction for the jacking arrangement. Meanwhile, respective signalling and indication on the main control panel of MODU is to be verified;

equipment for remote (automated) control of pumps and valves of the ballast and bilge system by means of several starts from the MODU main control panel. Simultaneously, respective signalling and indication is checked;

protection and alarm systems — control of the MODU hull position, control of air and ventilation of enclosed spaces maintained in overpressure by means of simulation of conditions of actuation of master instruments.

3.4.4.6.2 The following items are to be checked on MODU without regard of the automation distinguishing mark:

MODU jacking system remote control system;

remote control system for pumps and valves of the ballast-bilge system (except for self-elevating unit);

protection and alarm systems (control of hull working position, air control and ventilation of enclosed spaces maintained in overpressure).

3.4.4.7 The summary of the scope of survey of systems and piping during annual survey of MODU, drilling ships and FOP is set forth in Table 2.1.1, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships and Table 3.3 of the present Part.

3.4.4.8 During annual survey of systems and piping, check of systems in operation is to be synchronized with check of pumps, fans, hydromotors, heat exchangers and pressure vessels in operation.

3.4.4.9 MODU refrigerating plants are liable to survey as non-classed refrigerating plants.

The scope of the annual survey of the refrigerating plant is set forth in Table 3.3 of the present Part.

3.4.5 Electrical equipment.

3.4.5.1 The summary of the annual survey of the electrical equipment of MODU, drilling ships and fixed offshore platforms is set forth in Table 2.1.1, Part II "Survey Procedure and Scope" of Rules for the Classification Surveys of Ships and Table 3.3 of the present Part.

3.4.5.2 Drilling electrical equipment is not liable to the Register supervision except for :

explosion-proof electrical equipment which is located in dangerous rooms and spaces;

connected cables;

means of protection, insulation and earthing devices.

The said electrical equipment is liable to the annual survey. Due requirements are to be performed if it is detected during the survey of the said equipment that operation or technical condition of these equipment puts the human life in jeopardy or may cause fire or explosion.

The following items are checked during annual survey of the said equipment:

electrical equipment in all dangerous zones (only explosion-proof electrical equipment is to be fitted in dangerous rooms and spaces);

condition of all cable routing laid through explosive rooms and spaces;

condition of cable routing on the MODU movable parts (portals, towers, cranes etc.) and their protective arrangements;

condition of means of protection and earthing devices of electrical equipment of drilling unit including the rig and its substructure;

availability and condition of earthing of drilling mud and cement grout manifold as well as piping of pneumatic transport for powder materials and circulation system.

3.4.5.3 During annual survey of the electric propulsion plant its check in operation may be carried out without standing-pull and running trials. However, the following items are to be checked in all cases: steerability of electrical propulsion engines from all control stations; starting and reversing of electrical propulsion engines at a minimum rotational speed; operation of the propulsion plant at all possible regimes; operation of blocking and signalling devices envisaged in the diagram of electrical propulsion.

3.4.5.4 During annual survey of the MODU jacking system electrical machinery when MODU stands on the drilling location, check of drives in operation may be performed by means of check of electrical engines idle running and testing all programs of drive circuit by manual operation of limit switches.

During annual survey of electrical drives of the MODU jacking system machinery and electromagnet hydraulic jack control system, the following items are to be surveyed:

condition of electrical motors;

condition of electromagnetic coils;

condition of switching equipment (switches, changers, relays etc.);

sensors, limit switches.

3.4.5.5 During annual survey of electrical drives of submersible pumps, the following items are to be surveyed:

condition of bearing bushing in the upper and lower brackets;

condition of steel bushings on the electrical motor shaft;

condition of rubbing surfaces;

spacing between bearing bushings in brackets and respective bushings on the shaft.

3.4.5.6 During annual survey of the alarm system (strengthening of dangerous gas concentration, malfunctionining of the MODU jacking system, ventilation system of dangerous spaces, liquid level control in tanks, bilges, control of air pressure in the air blown electrical equipment) the following items are to be checked:

condition of signalling commutator, sensors;

source of noise and light in apparatuses;

all elements comprising alarm system.

3.5 SPECIAL SURVEYS

3.5.1 During special survey of the drilling unit, its hull, arrangements, equipment and outfit, machinery installation, electrical equipment are to be checked whether they meet requirements of the rules, regulating standards and technical characteristics, compound, structure, arrangement and installation of objects of supervision and their technical condition.

3.5.2 The scope of the special survey of specific items of supervision installed on the drilling unit is determined by the Register on the basis of Table 3.3 of the present Part for respective special survey keeping due note of age of unit and its technical condition.

3.5.3 Usually special survey includes survey of the drilling unit in dry dock.

3.5.4 Assessment of technical condition of hull structural members in terms of wear rate, damages and provisioning of impermeability in required cases is to be verified by calculation of wear and damage impact on provisioning of general and local strength.

3.5.5 During every special survey of hull members which are specific for MODU, the following items are liable to detail examination from outside: stability columns with bracings; columns of submersible sea water pumps; platforms, leg portals; drilling derrick portals with attachment points in a marching order, attachment points of members and plating of preventor stage (spider deck) to hull; attachment point of heliport to hull; foundations of drilling equipment, tensioning winch for guiding lines and risers; foundations for sub-sea equipment and jacking system of the submersible sea water pumps.

3.5.6 Since the second special survey the following items are liable to detailed examination: legs; footings, holes for legs, drilling derrick portal skids. During the first special survey only external examination is performed.

3.5.7 During every special survey the following items are to be examined from inside: legs (cylindrical form) and stability columns; holes for legs, for columns of submersible sea water pumps and drilling tools with bracings; strengthenings of foundations under drilling equipment and winches of guiding cables and riser tensioning systems; strengthening of foundations for underwater technical works, jacking system machinery for the sea water submersible pumps, rooms for drilling and cement pumps, drilling mud processing system and compressor stations.

3.5.8 During special surveys the following items are liable to detailed examination and hydraulic testing: drilling mud tanks; chemicals for drilling mud and cement grout, oil collection at a well trials; parts of stability columns and legs.

3.5.9 Testing of tanks and divisions is carried out by means of filling them with water up to upper end of air pipe.

3.5.10 Structures referred to in 3.5.5 to 3.5.8, except for working platforms, stability columns with bracings, foundations under drilling equipment and under winches of guiding cables and riser tensioning systems, are to be tested for absence of significant wear beginning from the third special survey. Measurement of residual thickness is to be performed by firms holding a Recognition Certificate. Value of allowed wear is calculated by design organisation and agreed with the Register.

3.5.11 During every special survey of closures: leg tanks; ballasting of pontoons, cementing of wells; for passage of cathodic protection cables, for examination of sea water submersible pumps — are liable to detailed examination and hydraulic tests, closures for surplus sea water discharge from sea water tank — beginning from the third special survey.

3.5.12 During every special survey operation of the following items: MODU jacking system; submersible sea water pump raising/submersion arrangements; MODU fixing arrangements are liable to detailed examination and testing in operation.

3.5.13 Spaces maintained in overpressure and their closures are to be examined and tested for ability to ensure required excessive pressure at each special survey.

3.5.14 Water intake system of the MODU sea water feeding system is to be tested in operation and examined during each special survey. Air control system is to be examined, checked in operation and tested by trial air pressure.

3.5.15 Fire-fighting equipment and heliport equipment is to be thoroughly examined during each special survey.

3.5.16 The following items are to be examined and tested in operation during each special survey: submersible sea water pumps; MODU jacking system machinery; raising/submersion arrangements for submersible sea water pumps.

3.5.17 Pressure vessels for marine riser and heave compensator systems and their fittings are to be surveyed internally and externally during each special survey as well as to pass hydraulic tests each 10 years, areas which are not available to full internal survey — each 5 years together with safety valves.

3.5.18 MODU hull position control system; automatic and remote control of MODU jacking system; automated control of valves and ballast system arrangements together with the alarm system and protection are to be subjected to detailed survey and test in operation during each special survey.

3.5.19 During each special survey the following items are to be subjected to detailed examination and test in operation: hydraulic drives of MODU jacking system and columns of sea water submersible pumps; MODU sea water feeding system; blowing and flooding system for leg tanks; ventilation of spaces maintained in overpressure; emergency drilling mud discharge system.

3.5.20 During each special survey the following items are liable to the detailed examination, test in operation and insulation measurement: electrical equipment of MODU jacking machinery and submersible sea water pumps and of pumps themselves, as well as selective emergency load switch-off devices.

3.5.21 During each special survey the following items are liable to the detailed examination and test in operation and measurement of insulation of signalling devices: air control, control of limiting values of MODU jacking system machinery and devices, position of remotely operated valves of the ballast and bilge systems, control of the liquid level in compartments and bilge wells, control of air pressure in the ventilation system of the spaces maintained in overpressure, failures of the ventilation system of dangerous rooms; control of water level in the sea water tank; MODU hull position control.

3.6 CONTINUOUS SURVEY SYSTEM

3.6.1 Upon the shipowner's request the continuous survey system of MODU/FOP classed by the Register may be supplemented by the continuous survey system providing for postponement of certain surveys of objects which are required during special survey for renewal of class for the period between special surveys of MODU/FOP in accordance with plan of submission of MODU/FOP in terms agreed between the shipowner and RS.

3.6.2 Continuous survey system is applied (jointly or separately) to all objects of the MODU/FOP hull (including ship arrangements and equipment, structural fire protection) machinery installations (including fire-fighting equipment and systems, electrical equipment, automation equipment) refrigerating plant.

3.6.3 Continuous survey system is not applied to survey of MODU/FOP in accordance with international conventions and agreements as well as survey of shafting and propellers, heating boilers, pressure vessels and apparatuses, steam lines and air ducts.

3.6.4 Use of the continuous survey system doesn't alter periodical surveys, the scope and terms of the MODU/FOP annual surveys, the order and terms of the special survey as well as the order of submission of MODU/FOP to occasional survey prescribed by the system.

3.6.5 Use of the MODU/FOP continuous survey system is fixed by respective note in the Classification Certificate and Appendix thereto Continuous Survey List which contains a list of objects of survey, brief description of survey and survey scheduled dates.

3.6.6 The character and the scope of survey of items distributed among special surveys and the order of their performance are to comply with the requirements prescribed for the special survey for renewal of MODU/FOP class according to its age.

3.6.7 The period between two successive surveys according to the continuous survey system is not to exceed validity period of class.

3.6.8 MODU/FOP to which the continuous survey system is applied is to be submitted for survey of due objects in terms fixed in the Continuous Survey List. Performance of survey is to be proved by the note in Continuous Survey List, which confirms validity of class if there are no other notes in the Classification Certificate.

3.6.9 The objects may be submitted to survey in advance (not earlier than three months). Upon agreement with the Register survey may be postponed within validity period of class between consecutive surveys of the same type.

3.6.10 If the object is not submitted to the scheduled survey in time set by the Continuous Survey List without postponement granted by the Register, the Register may apply sanctions aimed at termination of the use of this object, exclusion of the MODU/FOP from the continuous survey system with respective reduction of the term of submission to the special survey, suspension of class.

3.6.11 Some types of survey of objects in accordance with the continuous survey system may be performed by chief engineer upon consent of the Register and may be credited as the continuous survey provided the Register Surveyor carried out confirming survey.

3.6.12 The closing stage of the continuous survey is the next survey of MODU/FOP for renewal of class, which is carried out in terms agreed in the periodical survey system. The scope of this survey doesn't include surveys of objects which have been performed before in accordance with the Continuous Survey List still if there are sufficient grounds a Surveyor may require repeated survey of these items or their parts.

3.6.13 During this survey a shipowner is to submit a new Continuous Survey List to the Register Branch Office for the next period keeping due note of the actual submission of items in the previous period.

3.6.14 More detailed description of the continuous survey system is provided in the Instruction for Continuous Survey.

3.7 SURVEY PRIOR TO ISSUE OF STATUTORY DOCUMENTS

3.7.1 The main document which confirms performance of execution of safety requirements is the MODU Safety Certificate (1989) which is issued on the basis of provisions of the IMO Code on Construction and Equipment of MODU (1989) adopted by Resolution A.649 (16) October 19, 1989.

3.7.1.1 Since the requirements of the present Rules comply with the requirements of the said Code then MODU/FOP built in accordance with the present Rules and holding the class of the Register may obtain the MODU Safety Certificate (1989) upon results of the initial survey for the 5 year period.

3.7.1.2 As regards life-saving appliances and outfit MODU/FOP are to comply with the requirements of SOLAS 1974/78 in the scope referred to in the said Code. Unless otherwise is provided, then definitions used in Regulation III/3 SOLAS 1974/78 are to be used in respect of life-saving appliances. Life-saving appliances are to be assessed, tested and approved as set forth in Regulations III/4 and III/5 SOLAS 1974/78.

3.7.1.3 Drilling ships, MODU/FOP are to be fitted with fire-proof lifeboats which are capable to accommodate the total number of people aboard. Furthermore, each ship is to be equipped with a liferaft or liferafts complying with the requirements of Regulation III/39 or III/40 SOLAS 1974/78 which may be launched from any side of a unit, which total capacity is sufficient to accommodate the total number of people aboard. If a liferaft or liferafts can't be quickly moved to other side of a unit for submersion, the total capacity of liferafts installed on every side of unit is to be sufficient to accommodate the total number of people aboard.

3.7.1.4 As regards drilling ships, MODU/FOP an additional liferaft is to be installed in the bow or aft end off the main liferafts if the latter are located more than 100 metres one from another. As regards MODU/FOP life-saving appliances are to be located in the opposite sides or ends of a unit.

3.7.1.5 One rescue boat is to be installed on every unit. Life boat may be accepted as a rescue boat provided it meets requirements for rescue boats.

3.7.1.6 As regards installation of lifeboats and liferafts, measures ensuring submersion and raising of lifeboats and liferafts; measures ensuring assembly and boarding of people in lifeboats and liferafts — requirements of the above Code repeat or concretise requirements of SOLAS 1974/78. For instance, at least two fixed metal ladders or two stairways stretching from the deck to the water surface located far from each other. Fixed metal ladders or stairways and surrounding part of sea are to be sufficiently lightened by means of emergency source of power. If fixed ladders can't be installed then equal means of evacuation with sufficient throughput are to be provided to enable all people onboard to lower to the waterline safely.

3.7.1.7 The above Code specifies more exactly requirements of MODU supply with life buoy, life jackets, immersion suits. Sufficient number of life jackets and immersion suits is to be stored in locations convenient for those people whose life jackets and immersion suits are not easily accessible.

3.7.1.8 Requirements for radio equipment of life-saving appliances of MODU/FOP are similar to the requirements for the sea-going ships — three VHF radiotelephone apparatuses and two radar transponders are to be installed on every unit.

3.7.1.9 12 parachute signal rockets and line throwing arrangement are to be provided onboard MODU/FOP during survey.

3.7.1.10 During survey of life-saving appliances it is to be confirmed that all life-saving appliances are in working order and are ready for immediate use:

drawings and instructions are to be provided to show how to use controls and methods of their operation;

maintenance guidelines for the life-saving appliances are available;

spare parts and repair accessories are available;

weekly, monthly and other verifications are carried out;

maintenance of inflatable liferafts, hydrostatic release unit, inflatable rescue boats is carried out in due terms.

3.7.2 Freeboard.

3.7.2.1 All drilling units are covered by the requirements of the International Convention on Load Lines 1966 including those concerning issue of certificates and certificates are to be issued in due order. If the minimum freeboard can't be calculated by usual methods determined by this Convention, it is to be determined on the basis of satisfaction of applicable requirements in respect of intact stability and damage stability requirements and structural requirements in respect of condition of a unit during passage and performance of drilling afloat. The freeboard is to be not less than that calculated in accordance with the Convention provisions if applicable.

3.7.2.2 Requirements of the International Convention on Load Lines 1966 in respect of the watertightness of decks, superstructures, deckhouses, scuppers of water inlet/outlet are to be taken for the basis for all units afloat. During survey closures of all holes through which internal spaces may be flooded are to be checked: cargo and companion hatches, air pipes, air trunks, watertight doors. Windows, side scuttles and dead lights or other similar holes are not to be located below deck structures of the unit with stability columns.

3.7.3 Pollution prevention.

3.7.3.1 MARPOL 73/78 requirements for the ships which are not oil tankers (capacity is 400 and more) are to be fulfilled on all types of MODU/FOP.

3.7.3.2 International oil, sewage, garbage pollution prevention certificates may be issued to the ship upon fulfilment of respective requirements of the said Convention. If requirements in respect of prevention of air pollution are fulfilled respective certificate may be issued to the unit.

3.7.4 Cargo handling gear.

All cargo handling gear used for moving materials, equipment and staff between drilling unit and service ships are to be surveyed by the Register during construction and assembly performed on drilling unit. The Certificate of Testing may be issued to a cargo handling gear for a 5 year period upon execution of tests by trial cargo provided it is confirmed on an annual basis.

4 TECHNICAL DOCUMENTATION

4.1 TECHNICAL DESIGN OF A UNIT UNDER CONSTRUCTION

4.1.1 General requirements.

Before construction technical documentation referred to in 4.1.2 to 4.1.11 is to be submitted for consideration and approval of the Register.

4.1.2 General.

4.1.2.1 Technical specification.

4.1.2.2 General arrangement diagram with configuration of the unit.

4.1.3 Hull documentation.

4.1.3.1 Presented drawings are to define scantlings, structure, types and sorts of material exactly as well as specialities of hull structure and welding. Where possible drawings are to contain the following information:

.1 longitudinal section showing scantlings;
.2 transverse section showing scantlings;
.3 location of fixed and variable masses;
.4 plans of design loads for each deck;
.5 decks (including helideck);
.6 midship section;
.7 shell plating;
.8 watertight bulkheads and platforms;
.9 structural bulkheads and platforms;
.10 tank boundaries with location of overflows;
.11 supports and stringers;
.12 bracing members;
.13 legs;
.14 structure in way of elevating arrangements;
.15 stability and intermediate columns;
.16 hulls, pontoons, footings, pads and mats;
.17 superstructures and deckhouses;
.18 heliports;
.19 arrangement and structural details of the watertight doors and hatches with indication of height of their sills and coamings;
.20 technology and details of welding;
.21 non-destructive tests and location of items subjected to these tests.

4.1.3.2 The following data and calculation are to be attached to the drawings:

.1 analysis of resistance of joints to certain loads;
.2 resultant of forces and moments incurred by wind, water, current, mooring and other loads from environment which are taken into account while performing the analysis of joint strength;
.3 influence of icing on loads applied to the structure, stability and surface of wind exposure;
.4 working loads caused by the drilling unit and its respective appliances in the supporting structure as well as other significant loads of the same type;
.5 calculations which prove fitness of structure and transmission of forces arising between the support and hull by the cargo handling gear;

.6 assessment of the unit resistance to overturning when it stands on the seabed;

.7 results of respective model tests which may be used for justification or refinement of calculations.

4.1.4 Documentation on arrangements, equipment and outfit.

4.1.4.1 Layout diagram of closures.

4.1.4.2 General layout of arrangements: anchor arrangement required by the present Rules, steering gear, drilling ships mooring arrangement towing arrangement, MODU jacking system, arrangements for raising/submersion of columns of the submersible sea water pumps, MODU fixation arrangement; drawings of rudder and rudder stock.

4.1.4.3 Calculation of arrangements: anchor arrangement required by the present Rules, steering gear, drilling ships mooring arrangement, towing arrangement, MODU jacking system, arrangements for raising/submersion of columns of the submersible sea water pumps, MODU fixation arrangement; strength calculation of closures (for reference purposes).

4.1.4.4 Arrangements and equipment test program.

4.1.5 Stability documentation.

4.1.5.1 Lines drawing, hydrostatic curves of areas and static moments of frames.

4.1.5.2 Cross curves of stability.

4.1.5.3 Water displacement and position of center of masses of spaces and tanks.

4.1.5.4 Correction tables keeping due note of influence of free surfaces of liquid on stability.

4.1.5.5 Unit flooding curve angle.

4.1.5.6 Information on Stability.

4.1.6 Subdivision documentation.

4.1.6.1 Calculation of buoyancy after flooding of a compartment.

4.1.6.2 Calculation of stability of the damaged unit after flooding of a compartment.

4.1.6.3 Arrangements for heeling compensation after casualty accompanied by required calculations.

4.1.6.4 Information on resistance to flooding accompanied by the plan of watertight compartments, layout of holes and types of their closures as well as location of arrangements for heeling compensation.

4.1.7 Freeboard calculation.

4.1.8 Fire protection documentation.

4.1.8.1 Location of fire bulkheads separating MODU/FOP on fire zones and other fire-proof and fire retarding bulkheads with indication of doors, closures, passages and ducts etc.

4.1.8.2 MODU/FOP general diagram with indication of routes of escape and emergency exits to the open deck.

4.1.8.3 The following stations are to be located on MODY/ FOP: fire, central control, station for separate operational conditions.

4.1.8.4 Fire signalling and air control systems.

4.1.8.5 Diagrams and calculations of fire systems (pumps, foam fire-fighting arrangements etc.).

4.1.8.6 Detailed description of fire protection of drilling unit with indication of applied insulation and finishing materials, places of their application and their combustibility.

4.1.8.7 Comprehensive data about combustibility and fire hazard of those materials which are used for the first time.

4.1.9 Documentation on machinery installation and boiler plants.

4.1.9.1 The following documentation is to be submitted during next approval of working plans:

.1 technical documentation specified in 3.1.8.1, Part I "Classification"of the Rules for the Classification and Construction of Sea-Going Ships as far as it may be applied to MODU and drilling ship;

.2 drawings of the main control stations for remote control of raising, submersion and fixation of MODU hull, principal diagrams of control units accompanied by description of working principles, blocking systems, protection and signalling;

.3 diagram of propeller controlling systems;

.4 drawings and calculation of the MODU jacking system machinery.

4.1.9.2 The following documentation is submitted without further approval of the working plans:

.1 documentation as per 4.1.9.1;

.2 documentation as per 3.1.8.2, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships as far as it may be applied to MODU, FOP and drilling ship.

4.1.10 Automation documentation.

4.1.10.1 The following documentation is to be submitted during further approval of working plans:

.1 technical documentation specified in 3.1.9.1, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships as far as it may be applied to MODU, FOP or drilling ship;

.2 diagrams and drawings of jacking system automation of self-elevating units;

.3 diagrams and drawings of jacking system automation of semi-submersible units;

.4 diagrams and drawings of automation systems of submersible sea water pumps and of their raising and submersion arrangements;

.5 diagrams and drawings of automation systems of windlasses, winches and other deck machinery;

.6 diagrams and drawings of MODU draft, heel, trim, etc., measuring and recording devices;

.7 diagrams and drawings of other automation systems of essential machinery and arrangements as required by the Register.

4.1.10.2 The following documentation is to be submitted without further approval:

.1 documentation in accordance with 4.1.10.1;

.2 documentation in accordance with 3.1.9.2, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships as far as it is applicable to MODU, FOP or drilling ship.

4.1.11 Systems and piping documentation.

4.1.11.1 The following documentation is to be submitted for further approval of the working plans:

.1 technical documentation specified in 3.1.10.1, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships as far as it may be applied to MODU, FOP and drilling ship;

.2 hydraulic system diagram for driving MODU raising and fixation machinery and devices;

.3 hydraulic system diagram for raising and submersion of submersible pump columns;

.4 MODU sea water supply system diagram;

.5 diagram of system for charging and transfer of fuel for helicopters;

.6 ventilation system diagram with indication of watertight and fire bulkheads, location of fire flaps, ventilation capacity and air changes per hour for some spaces and dangerous zones as well as pressure in some rooms in this zones;

.7 strength calculations for hydraulic piping system for driving machinery and arrangements of raising and fixation of MODU hull;

.8 drilling mud emergency discharge system.

4.1.11.2 The following documentation is to be submitted without further approval of the working plans:

.1 documentation in accordance with 4.1.11.1;

.2 documentation in accordance with 3.1.10.2, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships as far as it may be applied to MODU, FOP and drilling ship;

.3 laying diagram for technological complex systems.

4.1.12 Electrical equipment documentation.

4.1.12.1 The following documents are submitted during further approval of the working documentation:

.1 technical documentation specified in 3.1.11.1, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships as far as it may be applied to MODU, FOP and drilling ship;

.2 diagrams and drawings of electrical drives of jacking system of self-elevating units;

.3 diagrams and drawings of electrical drives of jacking system of semi-submersible unit;

.4 diagrams and drawings of electrical drives of submersible sea water pumps and self-elevating unit raising arrangements;

.5 diagrams and drawings of alarm systems specified in Section 7, Part X "Electrical Equipment" of MODU/FOP Rules;

.6 plan of dividing unit into dangerous zones with a list of electrical and mechanical equipment mounted in each zone (including technological drilling equipment) with indication of closures of some rooms;

.7 diagram of emergency selective de-energizing of the electrical drives.

4.1.12.2 The following drawings are submitted without further approval:

.1 documentation in accordance with 4.1.12.1;

.2 documentation in accordance with 3.1.11.2, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships as far as it is applicable to MODU, FOP and drilling ship.

4.1.13 Documentation for marine operations.

4.1.13.1 Guidelines for marine operations.

4.1.13.2 The layout declaration for marine operations.

4.2 TECHNICAL DESIGN DOCUMENTATION FOR CONVERSION OR RECONSTRUCTION

4.2.1 Before conversion or reconstruction of the drilling unit the documentation for those parts of hull, machinery and equipment of the drilling unit which are liable to conversion and reconstruction are to be submitted to the Head Office.

4.2.2 If a new machinery and arrangements significantly varying from those initial ones and covered by requirements of MODU/FOP Rules are mounted on the drilling unit which is in operation it is necessary to submit to the Register an additional technical documentation on these new machinery and installations for review and approval in the scope required for the drilling unit under construction (see 4.1).

4.3 WORKING PLANS FOR MODU/FOP UNDER CONSTRUCTION

4.3.1 In case of approval of the technical documentation specified in 4.1.3, 4.1.4, 4.1.9, 4.1.10 and 4.1.12 the working plans in the scope agreed with the Register in each particular case are to be submitted to the local Register Branch Office for approval. Meanwhile, data contained in 3.3, Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships may be used as far as they are applicable for this unit.

5 CLASSIFICATION OF MODU/FOP WITH AN ASSIGNED CLASS OF ANOTHER CLASSIFICATION BODY

5.1 The following documents are to be submitted when MODU/FOP classed by other classification body is submitted for classification.

5.1.1 Documents of the classification body, certificates, data sheets, drawings and documents listed in 8.5, Part I "General Provisions" of the Rules for the Classification Surveys of Ships.

5.1.2 Drawings of legs, columns of submersible sea-water pumps, jack houses, substructure for drilling derrick with elements when stowed for transit, tanks and footings of legs, drill floors of submersible and semi-submersible units, jacking system and fixing arrangements of self-elevating units, location of dangerous zones with indication of their category, arrangement of all electrical equipment and cabling in dangerous zones and areas, remote central control stations of jacking system of self-elevating units.

5.1.3 Information on the MODU/FOP stability on the ground under the effect of wind, wave, current, weight and buoyancy, etc.

5.1.4 Elementary diagrams of control, interlocking, protection and alarm systems of the electric drives of the jacking system of self-elevating unit with indication of their technical characteristics, arrangements for raising and submersion of sea water pipe and submersible sea water pumps, the electrical remote control systems for these drives, protection and alarm systems.

5.1.5 Description of principle of operation of control, interlocking, protection and alarm systems of the remote control devices of jacking system of a self-elevating unit.

5.1.6 Operating Manual for MODU/FOP.

5.1.7 Conclusion of competent bodies on fire and explosion safety of MODU/FOP components related to the operation of the drilling equipment.

PART II. HULL

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part apply to:

.1 steel self-propelled and non-self-propelled mobile offshore drilling units (MODUs) whose types are defined under 1.2, Part I "Classification" of MODU/FOP Rules;

.2 tension leg platforms (TLP), the types of which are specified in 1.2, Part I "Classification" of MODU/FOP Rules. The TLP hull is supposed to be made of steel, and be provided with the steel concrete ice belt for ice resistant TLP; tension legs are to be made of steel, foundation may be made of steel, concrete/reinforced concrete or composite;

.3 steel, concrete and composite fixed offshore platforms (FOPs) including ice-resistant ones which are held to the bottom by gravity, with piles or be a combination of both, and whose types are defined under 1.2, Part I "Classification" of MODU/FOP Rules.

1.1.2 The application of the provisions of this Part to MODU/FOP types not covered by 1.2, Part I "Classification" of MODU/FOP Rules is subject to an agreement of the Register.

1.1.3 The present Part contains provisions aimed at ensuring the strength of MODU/FOP hull elements. If alternative approaches to strength analysis are used, they are to be agreed with the Register. The safety level ensured for the structure is to be at least the same as stipulated in the MODU/FOP Rules.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations pertinent to the general terminology of the present Rules are to be found in General Regulations for the Classification and Other Activity, in the Rules for the Classification and Construction of Sea-Going Ships and in Part I "Classification" of MODU/FOP Rules.

1.2.2 For the purpose of this Part, the following definitions have been adopted.

MODU/FOP hull is an aggregate of structural elements of a MODU/FOP which are to take up all the total and local, constant and alternating loads. Where a MODU/FOP hull is composed of independent (but in all cases interconnected) elements, such as legs and stability columns, underwater stability block, pontoons, braces, abovewater hull (upper bearing structure), the term "hull structure" can be used with respect to these.

Upper structure is the upper section of a MODU/FOP designed to accommodate equipment and attendants, and not involved in the overall hull strength ensurance.

Structural elements are sections of shell and plating, built-up girders manufactured by welding and rolling, components of shell and plating with adjacent frames, etc.

Tension leg is a system of elements connecting hull and subsea foundation aimed at TLP mooring.

Ground foundation (anchor) is an underwater TLP element fixed at the seabed.

Raiser is a system of piping and equipment aimed at connecting a borehole with the platform and supplying the platform with the extracted product.

1.3 SCOPE OF SUPERVISION

1.3.1 The hull (hull structures) of MODU/FOP are covered by the requirements of General Regulations for the Classification and Other Activity and of the Rules for the Classification and Construction of Sea-Going Ships.

1.3.2 The following structures of MODU/FOP (depending on the type of technical construction) are subject to manufacture supervision:

shell plating and framing of legs and stability columns, pontoons, underwater stability block, braces, upper hull, upper bearing structure, etc.;

watertight bulkheads and tanks;

decks and platforms;

helicopter decks;

superstructures and deckhouses;

jack houses;

coamings, companions and other guards of openings in MODU/FOP hull;

foundations of main and auxiliary machinery including those of other items subject to supervision;

substructure of drilling derrick.

1.3.3 Prior to the manufacture of the structures listed under 1.3.2, hull documentation is to be submitted for the Register consideration in the scope stipulated in 4.1.3, Part I "Classification" of MODU/

FOP Rules. Besides, the following documents are to be submitted:

.1 basic data, i.e. comprehensive data on ambient conditions (wind, sea, tide, ice, seabed, seismicity, temperature) in regions of MODU/FOP operation that correspond to the requirements of 2.2.

Data may be used, as contained in Appendix 1, as well as other data on ambient conditions, provided these are agreed with the Register in advance;

.2 operating mode description, i.e. the volume of data on the operating modes of a MODU/FOP, as stipulated in 2.3. Additional operating modes may be considered which agree with the features of the MODU/FOP in question;

.3 strength calculations to the minimal extent necessary for the hull strength confirmation on the basis of criteria adopted for the modes of MODU/FOP operation that may bring about a critical state of the structure. The methods of calculation are to be approved by the Register;

.4 MODU/FOP operating manual including the following:

brief description of the unit;

list of operating modes;

permissible values of parameters essential for the MODU/FOP safety in a particular operating mode;

loading conditions of a MODU/FOP in each operating mode;

instructions for the crew on the MODU/FOP maintenance in each operating mode;

instructions on the safe operation techniques of a MODU/FOP;

drawings with indication of the grades and strength of steels used for MODU/FOP structures, list of permissible welding procedures and welding consumables. Where necessary, additional instructions on welding consumables and welding may be given which may include possible restrictions and conditions for repair or conversion.

1.4 STRUCTURAL ELEMENTS

1.4.1 The structural elements of MODU/FOP are to be classified into special, primary and secondary elements proceeding from stress levels and the effect their eventual damage may have upon the strength and serviceability of the technical construction.

1.4.1.1 Special structural elements are those which ensure the overall strength of the structure and are subjected to the highest level of stresses due to total and local loads including alternate ones. In most cases, these members ensure the fatigue strength of the hull.

1.4.1.2 Primary structural elements are those which ensure the overall structural strength and integrity (if required proceeding from service conditions), as well as those whose importance is due to their role in the attendants safety ensurance.

1.4.1.3 Secondary structural elements are those which, when damaged, do not substantially impair the safety of the technical construction.

1.4.2 Structural elements of a semi-submersible unit.

1.4.2.1 Special elements:

shell plating in way of stabilizing column connections to decks and lower hulls;

deck plating, stiffened web girders and bulkheads of upper hull or platforms forming box or T-shaped bearing structures in areas subjected to considerable concentrated loads;

main bracings intersections;

semibulkheads, bulkhead and platform sections, as well as framing taking up considerable concentrated loads at intersections of bearing structure elements;

structural elements fitted for load transmission at intersections or connections of main bearing structures.

1.4.2.2 Primary elements:

shell plating of stabilizing columns, upper and lower hulls, and bracings;

deck plating, bulkheads and stiffened web girders of upper hull which form box or T-shaped bearing structures not subjected to considerable concentrated loads.

1.4.2.3 Secondary elements:

internal structures including the bulkheads and recesses of stabilizing columns and lower hulls, leg and bracings framing;

upper platform or upper hull decks except areas where these elements are primary or special ones;

large-diameter stabilizing columns with small length-to-diameter ratios except the connections of a column or intersections.

1.4.3 Structural elements of self-elevating units.

1.4.3.1 Special elements:

vertical legs in way of their connections to footings;

intersections of truss-type leg elements with welded components including steel castings.

1.4.3.2 Primary elements:

shell plating of tubular legs;

shell plating of all elements of truss-type legs;

bulkheads, decks, side and bottom plating of upper hull which form box or T-shaped bearing structures;

jack house structures of legs and footings, which take up the loads from legs.

1.4.3.3 Secondary elements:

inner framing including bulkheads and web framing members of tubular legs;

inner bulkheads and recesses, as well as framing members of upper hull;

inner bulkheads of leg footings except areas where the elements are principal or special ones;

deck plating, side and bottom shell plating of upper hull except areas where the elements are primary or special ones.

1.4.4 Structural elements of FOP.

1.4.4.1 Special elements:

structural elements of "skirt" and elements fitted in areas where the skirt is mated to the FOP bottom;

structural elements of ice strake where the platform is an oil reservoir;

structural elements in way of hull structural connections by which the overall strength is ensured, and in areas where the cross section varies abruptly;

structural areas subjected to considerable concentrated loads.

1.4.4.2 Primary elements:

shell plating of hull structures;

watertight bulkhead plating, watertight platform plating by which the overall strength is ensured;

web girders of hull structures;

main framing of shell plating, bulkhead plating, deck plating by which the overall hull strength is ensured.

1.4.4.3 Secondary elements:

inner structures not contributing to the overall hull strength;

auxiliary framing of shell plating and plating.

1.4.5 Structural elements of hull, ground foundation and TLP tension legs.

1.4.5.1 Special elements:

hull structures of a multi-column TLP as specified in 1.4.2.1 for the semi-submersible units;

hull structures of a tower-shaped TLP, such as:

structural elements of ice belt where the platform is an oil reservoir;

structural elements in way of hull structural joints by which the overall strength is ensured, and in the areas where the cross section varies abruptly;

structural areas subjected to considerable concentrated loads;

hull structural elements of TLP and ground foundation, interacting with tension legs;

interaction areas of tension legs, the hull and ground foundation and high voltage elements of the devices for tension maintenance in tension legs.

local areas of tension legs subject to possible high tension impact (coupling, welded transverse joints etc.);

areas of ground foundation exposed to substantial loads.

1.4.5.2 Primary elements:

hull structures of a multi-column TLP as specified in 1.4.2.2 for the semi-submersible units;

hull structures of a tower-shaped TLP as specified in 1.4.4.2 for the FOP;

tension legs and their elements, except for the areas, in which the elements are special;

structural elements of the ground foundation, except for the areas, in which the elements are special.

1.4.5.3 Secondary elements:

the hull structures of the multi-column and tower-shaped TLP, as specified in 1.4.2.3 and 1.4.4.3 for the semi-submersible units and FOP, respectively.

No structural elements of tension legs or anchors as well as the areas of hull and tension leg joints are to be classified as the secondary structural elements

1.4.6 The final classification of MODU/FOP structural elements is to be carried out by the designer and is to be agreed with the Register.

1.5 MATERIALS

1.5.1 Steel structures.

1.5.1.1 To be used for the manufacture of MODU/FOP structures are steels approved by the Register, which comply with the requirements of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and of Part XII "Materials" of MODU/FOP Rules.

1.5.1.2 The steel grade for particular structural element of MODU/FOP is to be determined from Table 1.5.1.2 proceeding from the design temperature of the structural material and the importance of the element as per the requirements of 1.4.

In cases not covered by this Table, application of steel is possible only upon agreement with the Register on the basis of viscosity and cold resistance properties obtained during tests under programmes agreed with the Register (see 1.3, Part XII "Materials"). List of necessary properties, requirements therefore and conditions for carrying out tests of steel with thickness up to 70 mm (inclusive) are defined in 3.2, Part XII "Materials". Table 1.5.1.2-2 gives categories of required tests depending on the structure loading conditions and type of structural element.

1.5.1.3 The design temperature for structural material will be determined either experimentally or by calculation proceeding from the minimal daily average temperature T_a adopted (see 1.2.3, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships). For the design ambient air temperature, see 2.2.7. In the absence of the above substantiations, the the design temperature of material of exterior abovewater structural elements is to be adopted equal to the ambient air temperature.

T a b l e 1.5.1.2-1

Structural elements	Steel grade for MODU/FOP	Design temperature of structural material, in °C						
		0	-10	-20	-30	-40	-50	-60
		Max. thickness of structural element, in mm						
Secondary	A	30	20	10	—	—	—	—
	B	40	30	20	10	—	—	—
	D	50	50	45	35	25	15	—
	E	50	50	50	50	45	35	25
	F	50	50	50	50	50	50	45
	AH	40	30	20	10	—	—	—
	DH	50	50	45	35	25	15	—
	EH	50	50	50	50	45	35	25
	FH	50	50	50	50	50	50	45
	AQ	40	25	10	—	—	—	—
	DQ	50	45	35	25	15	—	—
	EQ	50	50	50	45	35	25	15
	FQ	50	50	50	50	50	45	35
Primary	A	20	10	—	—	—	—	—
	B	25	20	10	—	—	—	—
	D	45	40	30	20	10	—	—
	E	50	50	50	40	30	20	—
	F	50	50	50	50	40	30	25
	AH	25	20	10	—	—	—	—
	DH	45	40	30	20	10	—	—
	EH	50	50	50	40	30	20	15
	FH	50	50	50	50	50	40	30
	AQ	20	—	—	—	—	—	—
	DQ	45	35	25	15	—	—	—
	EQ	50	50	45	35	25	15	—
	FQ	50	50	50	50	45	35	25
Special	B	15	—	—	—	—	—	—
	D	30	20	10	—	—	—	—
	E	50	45	35	25	15	—	—
	F	50	50	50	45	35	25	15
	AH	15	—	—	—	—	—	—
	DH	30	20	10	—	—	—	—
	EH	50	45	35	25	15	—	—
	FH	50	50	50	50	40	30	20
	DQ	25	15	—	—	—	—	—
	EQ	50	40	30	20	10	—	—
	FQ	50	50	50	40	30	20	10
N o t e . For intermediate temperature values, linear interpolation is permissible.								

T a b l e 1.5.1.2-2

Loading conditions, type of test	Structural elements		
	Special	Primary	Secondary
Cyclic, with direct application of dynamic ice or seismic loads			
Base metal: NDT for thicknesses up to 40 mm, T_{kb} for thicknesses in excess of 40 mm	See 3.2.4		
Heat-affected zone (HAZ) metal: CTOD	See Table 3.2.3-2		
Cyclic, with predominance of tensile and bending loads			
Base metal:			
NDT	See 3.2.5	See 3.2.5	NA
CTOD	See Table 3.2.3-1	See Table 3.2.3-2	See Table 3.2.3-2
Heat affected zone metal: CTOD	See Table 3.2.3-2	See Table 3.2.3-3	See Table 3.2.3-4
Static, cyclic with predominance of compressive loads			
Base metal: NDT	See 3.2.5	NA	NA
Heat-affected zone metal: CTOD	See Table 3.2.3-3	See Table 3.2.3-4	NA

Design temperature may be increased, if reliable evidence (obtained either by calculation or experiment) is provided to the Register that under service conditions the temperature of particular structural elements of MODU/FOP would not reach the minimal ambient air temperature stated in the specifications.

1.5.1.4 Special and primary structural elements taking up considerable loads directed through the thickness dimension of rolling are to be manufactured of Z-steel in accordance with the requirements of 3.14, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and of Part XII "Materials" of MODU/FOP Rules.

1.5.1.5 The design yield stress R_d of material should be determined from Table 1.5.1.5 proceeding from the standard yield stress R_{eH}.

1.5.1.6 The application of normal, higher and high strength steels with a thickness above 75 mm, as well as of steels for which $R_{eH} > 500$, in MPa, may be permitted by the Register after special consideration. For such steels, the design yield stress is to be agreed with the Register.

1.5.2 Reinforced structures.

Requirements for the materials of reinforced structures are to be found under 3.4.

1.6 WEAR OF STRUCTURAL ELEMENTS

1.6.1 The scantlings of MODU/FOP structural elements are to be assigned with due regard for corrosion allowance, and for shell plating in way of ice strake of ice-resistant FOP, allowance is to be made for surface abrasion with ice.

1.6.2 Wear allowance Δs, in mm, is to be made for the thickness of structural elements, as obtained by strength calculations, which is to be determined by the formula

$$\Delta s = kuT^* \tag{1.6.2}$$

where u = the design wear rate, in mm per year;
T^* = $T/2$ for MODU/FOP structural elements which can be repaired during service;
T^* = T for MODU/FOP structural elements which cannot be repaired during the whole period of the platform service;
T = the design service period of MODU/FOP, in years;
k = the factor accounting for the positive effect of protective measures to reduce wear ($k \leqslant 1$).

1.6.3 The design wear rate u is to be adopted on the basis of data on the wear of selected steels under conditions corresponding to the service conditions of MODU/FOP, the positive effects of wear reduction measures disregarded. In the absence of such data, the design wear rate may be adopted with due regard for the relevant requirements of the Rules for the Classification and Construction of Sea-Going Ships. In so doing, the congruity of service conditions of the MODU/FOP structural elements with those of the components for which data are given in the Rules for the Construction and Classification of Sea-Going Ships are to be borne in mind.

When adopting design corrosion rates for structural elements of semi-submersible units, one may be guided by the recommendations of Table 1.6.3.

1.6.4 The factor k accounting for the positive effects of protective measures to reduce wear may be adopted less than one, provided effective corrosion protection is used for structural elements, or special coats and materials are applied to prevent surface abrasion with ice. The factor is only to be introduced for the elements that are covered by protective measures.

1.6.4.1 $k = 0{,}5$ is to be adopted for the structures of semi-submersible units and FOP which are equipped with efficient corrosion protection systems, provided both the sides of the structural element are protected, and $k = 0{,}75$ is to be adopted where one of the surfaces of the structural element is protected.

1.6.4.2 The value of $k < 1$ is to be substantiated and agreed with the Register where the exterior structures of the ice strake of FOP are concerned on condition protective measures are taken to reduce wear.

1.6.5 $\Delta s = 1{,}0$ mm is to be the minimal corrosion allowance.

Table 1.5.1.5

Hull-structural steel	Steel grade for MODU/FOP	Standard yield stress R_{eH}, in MPa	Design yield stress R_d, in MPa, for thickness, in mm		
			< 30	30 — 50	50 — 70
A, B, D, E	A, B, D, E, F	235	235	215	200
A32 D32, E32, F32	AH, DH, EH, FH	315	315	295	280
A36, D36, E36, F36	AH, DH, EH, FH	355	355	335	320
A40, D40, E40, F40	AH, DH, EH, FH	390	390	370	355
A420, D420, E420, F420	AQ, DQ, EQ, FQ	420	420		400
A460, D460, E460, F460	AQ, DQ, EQ, FQ	460	460		440
A500, D500, E500, F500	AQ, DQ, EQ, FQ	500	500		480

Table 1.6.3

Recommended design corrosion rates for structural elements of semi-submersible units

Structural element	Design corrosion rate, in mm per year
1 Bracings:	
1.1 Horizontal transverse bracings	
in way of connections to columns and other bracings	0,18
outside the areas of connection	0,16
1.2 Horizontal diagonal bracings	
in way of connections to columns and other bracings	0,18
outside the areas of connection	0,14
1.3 Inclined transverse bracings	
in way of connections to columns, pontoons and upper hull	0,18
outside the areas of connection	0,16
1.4 Inclined longitudinal bracings	
in way of connections to columns and upper hull	0,15
outside the areas of connection	0,14
2 Columns:	
in way of connections to pontoons	0,14
on the level of alternating waterline	0,16
above-water structure	0,10
underwater structure	0,12
3 Pontoons:	
bottom, deck, sides of ballast and fuel compartments	0,16
bulkheads	0,14
bottom, deck, sides of dry compartments	0,13
4 Upper hull:	
sides and transoms	0,11
bulkheads	0,10
supporting beams	0,13
main deck	0,10
open sections of upper deck exposed to weather	0,13

1.7 WELDED STRUCTURES AND JOINTS

1.7.1 Welded joints of MODU and FOP structures are to meet the requirements of Parts II "Hull" and XIV "Welding" of Rules for the Classification and Construction of Sea-Going Ships and of Part XIII "Welding" of MODU/FOP Rules with regard to welded joints and structures, welding consumables, welding methods and quality control of welded joints.

1.7.2 Welded joints of special structures potentially subjected to excessive stresses across the rolled stock thickness are to be carried out so as to prevent or minimize the possibility of a layered rupture.

1.7.3 Weld dimensions are set according to approved national standards or technical documentation.

2 STRUCTURAL DESIGN PRINCIPLES

2.1 GENERAL

2.1.1 The design of MODU/FOP is to be such that its strength within the service life (as determined for environmental conditions of the anticipated area of operation) meets the accepted criteria in the following design conditions:

transportation;

positioning;

operating;

survival or extreme loading;

removal from the drilling location.

Besides, if necessary according to conditions of construction strength of structures or separate elements is to be verified during manufacture.

Adjustment of design conditions to the type of MODU/FOP is given in Section 3.

2.1.2 Designing MODU/FOP is to be carried out keeping due note of safe operation requirements including requirements for environmental safety during the whole service life of the structure as well as ensuring convenience of works related to survey/examination and current repair of structures.

2.1.3 It is recommended to equip MODU/FOP with instrumentation for observation of condition of hull structures in order to assess their reliability, timely detection of defects and increment of safety level.

2.1.4 Strength calculations are to be performed in respect of all structural elements of MODU/FOP: special, primary and secondary.

Dimensions of structural elements exposed to local loadings only and which don't contribute to general strength of the unit (platform) may be determined in accordance with applicable requirements of Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships.

2.1.5 Structural scheme and general arrangement of topside should consider safety requirements reducing risk of possible environmental exposures. In particular, the accommodation spaces are to be located from the side of dominating winds; rig and flare — on the opposite side etc.

2.1.6 MODU hull structures in the place of installation of positioning system machinery are to ensure taking up loadings equal to breaking strength of ropes and chains. Permissible stresses are to be not more than $0,95R_{eH}$.

2.2 ENVIRONMENTAL CONDITIONS

2.2.1 General.

2.2.1.1 The description of environmental conditions of the area of operation (sea or seas, area or part of sea area) is to include data on the ambient conditions which may influence the reliability of MODU/FOP, namely: wind, waves, current, ice, seabed, seismic exposure, air temperature etc).

2.2.1.2 The description of environmental conditions is to reflect the realistic character of wind and wave formation, currents and ice formation and is to be based upon probabilistic methods and statistical information.

2.2.1.3 The basic parameters of environmental conditions, as determined for the prescribed area of operation are to be agreed with the Register. Data on the wind and waves in different seas are given in Appendix 1.

2.2.1.4 If conditions of MODU/FOP operation are limited by the list of seas, area or part of the sea areas, seasons or permissible limits of environmental conditions then the list of seas, area borders or parts of these areas, seasons and permissible values of characteristics of environmental conditions for respective areas of operation are specified in MODU/FOP Operating Manual.

2.2.2 Wind.

2.2.2.1 There are following characteristics of the wind: average wind velocity at anemometer height ($z = 10$ m), law of change of wind average velocity by height, wind gustiness parametres, spectral characteristics of wind pulsations.

The basic data on the wind conditions are wind velocities $\overline{w}_{10}$ with the averaging period of 10 min at anemometer height ($z = 10$ m) which are called standard velocities and the period of recurrence in the region under consideration over the long period of not less than 20 years.

2.2.2.2 Extreme values of average wind velocities are determined from many years observations as most probable largest values with recurrence period of 100 years, but not less than 25,8 m/s.

2.2.2.3 The interrelation between $W_{\max}$ and average $\overline{w}$ velocities is determined by the gustiness coefficient G

$$W_{max} = G\overline{w};\ G = 1 + \gamma\vartheta_w \qquad (2.2.2.3)$$

where γ = numeric coefficient (see Table 2.2.2.3);
σ_w = standard deviation of wind velocities;
ϑ_w = coefficient of the wind velocity volatility (see 2.2.2.4)

$$\vartheta_w = \sigma_w/\overline{w}.$$

Table 2.2.2.3

Speed averaging period of 10 min	Duration of the maximum gust n						
	1	3	6	12	18	36	90
γ	2,94	2,58	2,52	2,10	1,90	1,55	1,00

Maximum velocity is calculated at averaging of n seconds. Recommended $n = 3$.

2.2.2.4 It is recommended to use the Davenport longitudinal wind pulsation spectrum

$$S(f) = \frac{4K_{hr}\overline{w}^2{}_{10}n^2}{f(1+n^2)^{4/3}} \qquad (2.2.2.4\text{-}1)$$

where $n = 1200\,f/\overline{w}_{10}$
f = frequency, Hz;
$\overline{w}_{10}$ = average wind velocity at hour averaging (m/s); transitional coefficients between different averaging periods are to be determined on the basis of Fig. 2.2.2.4;
K_{hr} = head resistance coefficient of underlying surface (see Table 2.2.2.4).

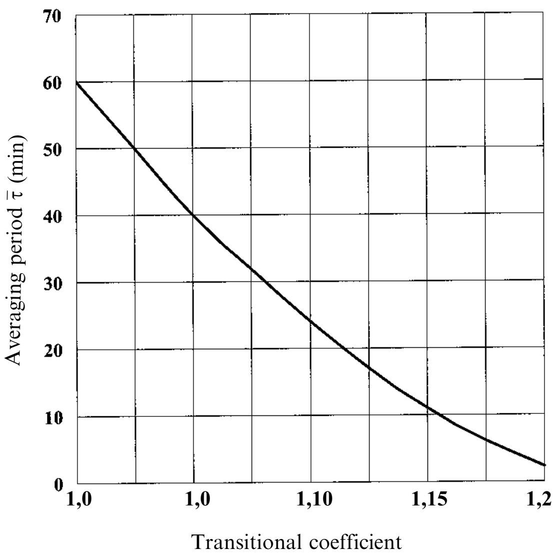


Fig. 2.2.2.4 Diagram of transitional coefficients v_τ/v_{60}

Table 2.2.2.4-1

$\overline{w}_{10}$, m/c	15	20	25	30
$K_{hr}10^3$	2,0	2,5	3,0	3,5

Wind velocity by height profile considering time of averaging is determined by the following formula:

$$\overline{w} = \overline{w}_{10}[1 + \ln(z/10)^{1/7}(10/t)^{1/20}] \qquad (2.2.2.4\text{-}2)$$

where t = the time of averaging, in min,

and according to the Table 2.2.2.4-2.

Table 2.2.2.4-2

Time / z, m	3 s	5 s	15 s	1 min	10 min	60 min
1,0	0,936	0,910	0,856	0,786	0,671	0,581
5,0	1,166	1,140	1,085	1,016	0,901	0,811
10,0	1,265	1,239	1,184	1,115	1,000	0,910
20,0	1,364	1,338	1,283	1,214	1,099	1,009
30,0	1,422	1,396	1,341	1,272	1,157	1,067
40,0	1,463	1,437	1,382	1,313	1,198	1,108
50,0	1,495	1,469	1,414	1,345	1,230	1,140
100,0	1,594	1,568	1,513	1,444	1,329	1,239

2.2.2.5 The variation of average wind velocities by height is shown by the following expression

open seas

$$\overline{w}_z = \overline{w}_{10}[1 + \ln(z/10)^{1/7}]\ ; \qquad (2.2.2.5\text{-}1)$$

coastal zones

$$\overline{w}_z = \overline{w}_{10}[1 + \ln(z/10)^{1/5}] \qquad (2.2.2.5\text{-}2)$$

where z = height above sea level, m; $10 \leqslant z \leqslant 100$ m.

2.2.3 Waves.

2.2.3.1 Waves are described by the following parameters: 3 per cent probability, wave height recurring once in 100 years, average wave period, average wave frequency, wave spectral density, average wave length, joint periodicity of wave heights and periods.

2.2.3.2 Joint recurrence of wave heights and periods is determined on the basis of information from specialized organisations for the given area of operation.

2.2.3.3 The ratio between the average period, average wave length and average frequency is to be employed in case of shallow water

$$\overline{\omega}^2 = \overline{K} g th \overline{K} H; \qquad (2.2.3.3\text{-}1)$$

$$\overline{\tau} = 2\pi/\overline{\omega} \qquad (2.2.3.3\text{-}2)$$

where $\overline{K}$ = wave number, $\overline{K} = 2\pi/\overline{\lambda}$;
$\overline{\lambda}$ = average wave length, m;
H = depth of water space, m.

2.2.3.4 The extreme values of wave heights are determined as the most probable largest wave heights with recurrence period of 100 years ($\tilde{h}_{100}$). In case of absence of information of their values $\tilde{h}_{100}$ may be determined by the formula

$$\tilde{h}_{100} = 0{,}38\sigma_{h_3}\ln n \qquad (2.2.3.4)$$

where $\sigma_{h_3} = \sqrt{\sum_i p_i h_{3i}^2}$;
p_i = recurrence of wave conditions which is featured by h_{3i} (value of column Σ_n of joint recurrence of wave heights and periods table);
$n = T/\overline{\tau}$;
T = period of time under consideration (T = 100 years);
$\overline{\tau}$ = average wave period over this time period

$\overline{\tau} = \sum_j p_j \overline{\tau}_j$;
p_j = value of column Σ_τ of joint recurrence of wave heights and periods table.

2.2.3.5 Two concepts may be employed to assess extreme values

the first concept is based on the long term distributions;

the second concept is based on the severest conditions;

The closed system of assessments implies the following interrelation of wave characteristics for these concepts:

$$h_{100} = 1{,}94(h_3)_{\max}; \qquad (2.2.3.5\text{-}1)$$

$$(h_3)_{100} = 2{,}94(h_3)_{\max} - 18{,}8 \qquad (2.2.3.5\text{-}2)$$

where $(h_3)_{\max}$ = wave height, m, of 3 per cent probability of stationary conditions at which the extreme value of the given exceedance is the most probable for realization;
$(h_3)_{100}$ = wave height, m, of 3 per cent probability recurring once in 100 years.

2.2.3.6 JONSWAP spectrum is the recommended design wave spectrum

$$S_J(\omega) = S_{PM}\gamma^{\exp[-(\omega-\omega_m)^2/2\sigma^2\omega_m^2\ ]} \qquad (2.2.3.6\text{-}1)$$

where S_{PM} = Pierson-Moskowits spectrum determined by the formula

$$S_{PM} = 10^{-2} h_3^2 \overline{\tau} (\omega/\overline{\omega})^{-5} \exp[-0{,}44(\omega/\overline{\omega})^{-4}]; \qquad (2.2.3.6\text{-}2)$$

$\overline{\omega} = 2\pi/\overline{\tau}$ = average wave frequency;
ω_m = frequency of spectrum maximum;
γ = ratio of S_J and S_{PM} maxima; average value $\gamma = 3{,}3$;
$\sigma = \sigma_a = 0{,}07$ for $\omega < \omega_m$;
$\sigma = \sigma_b = 0{,}09$ for $\omega > \omega_m$.

2.2.4 Current.

2.2.4.1 When influence of current is studied in the given area it is necessary to consider such factors like its nature (tide or wind), distribution by depth, stability over time.

In absence of information about the current profile in the area of operation under consideration it is recommended to use average statistical data from the following expression:

$$\upsilon_c = \upsilon_{c_1}[(H_0 - z)/H_0]^{1/7} + \upsilon_{c_2}[(H_0 - z)/H_0] \qquad (2.2.4.1)$$

where υ_c = general current speed at z depth from the water surface;
υ_{c_1} = high tide speed at a calm water level H_0;
υ_{c_2} = wind current speed at H_0 level.

2.2.4.2 When reviewing influence of current on parametres of external loadings affecting FOP/MODU, it is necessary to consider the effect of interaction of the current and waves. In the random wave field this leads to the transformation of the wave spectrum:

$$S_{\upsilon_T}(\omega) = \frac{4S_0(\omega)}{[1+(1+4\upsilon_c\omega/g)^{1/2}][(1+4\upsilon_c\omega/g)^{1/2}+(1+4\upsilon_c\omega/g)]} \quad (2.2.4.2)$$

where $S_0(\omega)$ = the spectrum of the surface waves;
$\upsilon_c > 0$ = conjunction of the wave and current directions;
$\upsilon_c < 0$ = head directions of waves and current.

2.2.5 Ice.

2.2.5.1 The following physical and mechanical properties characterize ice: density, salt content, compression strength, bending strength, tensile strength, modulus of elasticity, fracture toughness, friction behaviour.

2.2.5.2 Compression strength and bending strength depend on temperature, salt content, speed of application of load, conditions of straining. Ice strength is to be determined in respect of a specific area.

Compression strength and bending strength present random values.

Design values of compression strength $\overline{\sigma}_c$ and bending strength $\overline{\sigma}_f$ are to be average values with the recurrence period of 100 years, which are to be determined in respect of specific sea area according to special methodology agreed with the Register.

In absence of information on the values of $\overline{\sigma}_c$ and $\overline{\sigma}_f$ in the first averaging, the following values may be recommended:

$$\overline{\sigma}_c = \sigma_c^{100}(1-0{,}5\vartheta_{\sigma_c})\ ;$$
$$\overline{\sigma}_f = \sigma_f^{100}(1-0{,}5\vartheta_{\sigma_f}) \quad (2.2.5.2)$$

where σ_c^{100} и σ_f^{100} = the extreme values of compression and bending strength corresponding with the recurrence period of 100 years (1% probability);
ϑ_{σ_c} и ϑ_{σ_f} = variability coefficients of compression strength $\overline{\sigma}_c$ and bending strength $\overline{\sigma}_f$.

In the absence of information, the following values may be recommended as minimal values $\overline{\sigma}_c = 1{,}4$ and $\overline{\sigma}_f = 0{,}7$MPa.

2.2.5.3 The following geometrical properties characterize ice: thickness of level ice, thickness of rafted ice, thickness of consolidated layer of ridge, ridge height and ridge keel depth, ridge length.

2.2.5.4 Thickness of level ice is the function deriving from the number of frosty days and it is determined as a value of 1 per cent probability. The thickness of the rafted ice is taken as the basic in determination of the clearance of the upper structure.

2.2.5.5 Geometrical parameters of consolidated layer (thickness of consolidated layer of ridge, ridge height and ridge keel depth) are determined for 1 per cent probability.

2.2.5.6 Speed of ice drift is the initial information for assessment of the speed of deformation and assessment of ice forces when an impact is applied by ice formations to platform ("summer scenario").

2.2.5.7 The thickness of the level (rafted) ice and ice ultimate strength are treated as the statistically independent values which is an attribute of the annual ice.

2.2.6 Seabed.

2.2.6.1 For the area of MODU/FOP installation it is necessary to obtain engineering section of the foundation with indication of depth of stratum and information on normative and calculated value of the physical and mechanical properties of the foundation.

2.2.6.2 There are following attributes of the seabed: type of the seabed (sand, clay, silt etc.), wet soil weight, deformation modulus (statical and dynamical), Poisson's ratio, adhesion value, angle of internal friction, C_I — non-drained shift resistance, consolidation coefficient, porosity factor, humidity factor, seabed permeability, flow index.

2.2.7 Seismic conditions.

2.2.7.1 The main information on earthquakes in the seismically dangerous region is the intensity of seismic exposure which has a recurrence period over the long period of time — at least 100 years (design earthquake).

Extreme values of seismic exposure are determined on the basis of many years' experience and they are to be extrapolated as the most probable over 500 years (maximum design earthquake).

2.2.7.2 It is recommended to use a Russian scale based on maximum accelerations (see Table 2.2.7.2) for evaluation of earthquake force.

Table 2.2.7.2

Earthquake force $J^{initial}$	Seabed acceleration intervals (cm/s^2) at a period of 0,1 s and greater	Intervals between earth tremors (cm/s)	Intervals between movements of the centre of gravity of the seismometer pendulum "СБН" (mm)
6	30 — 60	3,0 — 6,0	1,5 — 3,0
7	61 — 120	6,1 — 12,0	3,1 — 6,0
8	121 — 240	12,1 — 24,0	6,1 — 12,0
9	241 — 480	24,1 — 48,0	12,1 — 24,0

Seismic exposure is to be considered if force of calculated seismic activity in the area of self-elevating unit/FOP operation is 6,5 and more.

2.2.7.3 The interrelation between the calculated seismical activity J_{100}^{calc} (J_{500}^{calc}) and attributes of the local seabed are determined in accordance with Table 2.2.7.3.

2.2.7.4 Evaluation of the seismical activity is to be matched with the existing Russian seismic charts.

2.2.8 Ambient air temperature.

The main source of information about ambient air temperature is information about the lowest average daily temperature in the possible area of

Table 2.2.7.3

Seismic categories of seabed	Seabed	Calculated seismic activity force J_{100}^{calc} (J_{500}^{calc}) based on the initial seismic activity of the area of operation $J_{100}^{initial}$ ($J_{500}^{initial}$)			
		6	7	8	9
I	Non-eroded and poorly eroded rocky seabed of all types (including many years frozen seabed in the frozen and melted condition); seabed of big fragmentary magma pieces, containing up to 20 per cent of sand and clay filler; speed of the transverse waves propagation $V_s \geqslant 700$ m/s; interrelation between speeds of longitudinal and transverse waves $V_p/V_s = 1{,}7$ — 2,2	–	6	7	8
II	Rocky seabed (except those referred to the I category); seabed of big fragmentary pieces (except those referred to the I category); dust-and-clay seabed with a flow index of $J_L \leqslant 0{,}5$, porosity factor $e < 0{,}9$ for clays and adobes and $e < 0{,}7$ for clay sand; many years non-rocky ductile and frozen or loose and frozen seabed; $V_s = 250 \div 700$ m/s, $V_p/V_s =$ 2,2 – 3,5	6	7	8	9
III	Loose sands without regard of fineness; semi-gravel sands of large and medium fineness, high or medium density, dust-and-clay seabed with the flow index of $J_L > 0{,}5$ at a porosity factor of $e \geqslant 0{,}9$ for clays and adobes and $e \geqslant 0{,}7$ for clay sand; many year frozen and rocky seabed with possible defrosting; silt seabed; $V_s \leqslant 250$ m/s, $V_p/V_s \geqslant 3{,}5$ — for saturated seabed	7	8	9	> 9

the platform operation which is taken from the meteorological historical data over at least 10 years if anything else is not provided in the present Part.

2.2.8.2 The minimal design temperature for the platform elements operating underwater at all times is taken for the water temperature -2 °C.

2.3 DESIGN CONDITIONS AND LOADINGS

2.3.1 Classification of loadings.

2.3.1.1 By their nature, all loadings affecting the MODU/FOP structure are grouped in two categories:

gravity loadings with relevant environmental loadings due to waves, wind, current, ice, seismic activity, seabed, temperature etc.;

the loadings caused by functioning of machinery, equipment, systems and associated with the operation of the MODU/FOP.

Each category may comprise fixed and variable loadings; the latter are determined as static or dynamic depending on structural response to external effects. Depending on the relative dimensions of the exposed area each of the above-mentioned loading categories is subdivided into common and local.

2.3.1.2 Fixed static loadings are those which do not change in value, location or direction if environmental conditions have changed. For a structure in calm water condition the gravity forces of this structure and all permanently secured equipment, as well as the buoyancy forces, the platform footing counterpressure (weighing), soil loadings and soil weight within the scope depending onthe scheme of the interaction between the platform and foundation are treated as the fixed static loading.

Variable static loadings are those which change in value and direction during a certain time period. However, the velocity of loading variation is so insignificant that it has practically no effect on the structure.

2.3.1.3 Dynamic loadings are those which change in value and direction enough quickly to produce a dynamic effect on the behaviour of the structure. The dynamic effect on the structure may be caused by wind blows, waves, ice, seismic factors.

2.3.2 Survival conditions or extreme loadings.

2.3.2.1 The loadings which have to be considered in strength calculations of MODU/FOP under extreme loadings include:

common and local variable and fixed extreme loadings caused by environmental exposure;

common and local functional loadings corresponding to extreme state of MODU/FOP in terms of safety.

2.3.2.2 For FOP extreme wind, wave, ice, current and temperature loadings are those of the maximum external loadings which may affect the platform over the 100 year period. The recurrence of seismic loadings is determined in relation to the agreed criterion (see 3.1.6 and 3.3.2.4).

For MODU the extreme variable loadings are those of the possible maximum external loadings which affect MODU over the whole operation period. The variable loadings which possibility of excess in the long term distribution is equal to 10^{-8} are taken for the design loadings.

Extreme impact loadings on the transverse horizontal bracing of the semi-submersible unit are the loadings caused by impact interaction with water during sailing the opposite course relative to the main wave system stationary wave conditions with maximum $h_{3\%}$ and T_{av} in the long-term mutual distribution of heights $h_{3\%}$ and T_{av} periods of waves in the area of operation, their probabillity is 10^{-4} for this wave mode.

2.3.2.3 The worst practical combinations of external loadings which may cause the largest tension of structures are to be considered.

2.3.3 Operating conditions.

2.3.3.1 The loadings which have to be considered in strength calculations of MODU/FOP in the operating conditions include:

common and local variable and fixed environmental loadings which intensity allows a unit to perform main functions;

common and local functional loadings corresponding to the operation mode.

2.3.3.2 The worst possible combinations of practical functional loadings which may cause the greatest stresses of structure are to be considered.

The loadings recurring once a year are taken for the design values of variable environmental loadings. The loadings which probability in the long term distribution is equal to 10^{-6} are allowed for MODU.

2.3.4 Transportation conditions.

2.3.4.1 Permissible transit conditions are to be determined for the transportation conditions and specified in the Classification Certificate and Operation Manual; the design of transit is developed for each transit which contains actions to ensure limitations imposed by environmental conditions and MODU/FOP safety during transportation. The design of transit is to be agreed with the Register.

2.3.4.2 Loadings which are to be dealt with in the MODU/FOP strength calculations during transportation include common and local fixed and variable loadings incurred by the environment and such functional loadings which cause the highest expansion in structures in conditions under consideration.

2.3.4.3 Loadings with 10^{-2} probability in the long term distribution in permissible environmental conditions are taken for design values of variable loadings.

2.3.4.4 Loadings with 10^{-4} probability during stationary wave conditions with $h_{3\%}$ and T_{av} permissible for the transportation conditions, at the specified $h_{3\%}$, in the long-term distribution during sailing at head seas are taken for design values of impact loads applied to semi-submersible unit bracings during transportation.

2.3.5 Conditions of positioning and removal from the drilling location.

Permissible environmental conditions are determined by the designer and they are liable to agreement with the Register. Structural strength calculations are to be made for the loadings corresponding to these conditions of loading.

2.3.6 Deck loadings.

The design loading on decks is to take into account the most unfavourable combination of functional loadings indicated in 2.3.1. In any case, the design loadings are not to be less than in Table 2.3.6.

Table 2.3.6

Designation of room/deck	Pressure q, kPa
Accomodation decks, walkways	4,5
Work areas	9,0
Storage areas:	
general purpose	7,85ρh, but not less than 13,0
for cement	9,81ρh, but not less than 13,5
Note. h = cargo stowage height, m; ρ = mass cargo density, t/m^3.	

2.3.7 Watertight bulkhead loading.

For the plating and framing of watertight bulkheads in ballast tanks, cargo or fuel oil tanks, the design pressure head, kPa, is determined by the dependence

$$p = 9{,}81\rho(h_0 + h_p) \qquad (2.3.7)$$

where ρ = mass density of ballast, cargo or fuel, t/m^3;
h_0 = vertical distance from the design point to the uppermost point of the compartment under consideration, m;
h_p = height of air pipe above the uppermost point of the compartment, m.

2.3.8 Wind loadings.

Wind loadings are determined by the formula

$$Q_w = 10^{-3}\rho_w(w_{10}^2/2)\sum_i S_i K_{1i} K_{2i} \qquad (2.3.8)$$

where Q_w = resultant of wind forces, kH;
ρ_w = mass density of air, kg/m^3;
w_{10} = design wind speed at the height of 10 meters above the calm water surface at 10 minutes averaging, m/s;
S_i = i-element windage area, m^2;
K_{1i} = coefficient allowing for the change of wind speed by height (see 2.2.2.5);
K_{2i} = i-element form strength coefficient (corresponds to Table 2.4.2.3, Part IV "Stability" of MODU/FOP Rules).

2.3.9 Hydrodynamic loadings.

2.3.9.1 Wave loadings on the platform and its elements are determined on the basis of the Moritz equation. For the single obstruction element, the vector of specific wave loadings $\{Q\}$, t/m, is shown by the following expression:

$$\{Q\} = \frac{\rho_\upsilon d C_{sp}}{2}\{|\upsilon - \dot{y}|(\upsilon - \dot{y})\} + \rho_\upsilon S\{\dot{\upsilon}\} + + \rho_\upsilon(C_{in} - 1)(\upsilon - \ddot{y}) \qquad (2.3.9.1)$$

where C_{sp} and C_{in} = speed and inertia resistance factors;
ρ_υ = mass density of water, ts^2/m^4;
S and d = cross section area, m^2, and diameter of obstruction at z level from water surface, m;
υ and $\dot{\upsilon}$ = orbital speed, m/s, and water particles acceleration m/s^2;
$\dot{y}$ and $\ddot{y}$ = speed and acceleration of the structural elements.

2.3.9.2 For the large obstruction diameters, *d* it is necessary to consider the diffraction effects. The proposed values of the diffraction coefficient K_υ are set forth in Table 2.3.9.2; the inertial component is directly proportional to K_υ, the speed component is proportional to K_υ^2.

Table 2.3.9.2

Relative obstruction dimension d/λ	0,05	0,10	0,15	0,20	0,25	0,30	0,40
K_υ	1,00	0,97	0,93	0,86	0,79	0,70	0,52

2.3.10 Current loadings.

Mutual exposure to wave and current is to be considered in accordance with the recommendations of 3.1.5.2.

Current loadings on MODU/FOP are determined in accordance with the recommendations of 3.1.5.1 to 3.3.2.2.

2.3.11 Combination of environmental loadings.

2.3.11.1 The most dangerous combinations of loadings in accordance with 2.3.1 to 2.3.5 are to be considered while calculating the MODU/FOP structural strength and buckling strength.

2.3.11.2 While reviewing the environmental loadings it is necessary to consider that there may be several environmental loadings acting at a time.

Combination of loadings is a subject to their statistical peculiarities.

During extreme loading of the structure it is allowed to use combination of common loadings in accordance with Table 2.3.11.2 in absence of the probability analysis.

2.3.12 Mooring impact loadings.

Attention is to be also given to impact loadings from supply vessels alongside the drilling unit as well as provisions of 3.8, Part II "Hull"of Rules fo he Classification and Construction of Sea-going Ships.

2.3.13 Towing operation loadings.

Towing operation loadings are the loadings on separate members of the unit arising during voyage in tow and consisting of:

fixed component which depends on the speed of unit in relation to water and wind;

variable component which depends on seaway and relative motion of unit and tow, conditioned by wave rocking.

2.4 STRENGTH CRITERIA

2.4.1 General.

2.4.1.1 MODU/FOP is to be so designed as to meet the following general safety requirement:

$$\Phi \leqslant R\eta \qquad (2.4.1.1)$$

where Φ = design value of the generalized force action (for instance, design internal forces, normal, shear or equivalent stresses, design deformations, shifts, design pressure upon plate etc.), which is used to assess marginal state;

R = design value of generalized carrying capacity (design strength of structure) determined by normative documents; this is usually the design yield strength of material or limiting pressure on elements, width of the cracks in concrete etc.;

η = safety factor which depends on the various structural elements responsibility for strength and safety of structure.

2.4.1.2 If requirement of 2.4.1.1 is met the following dangerous states can be practically avoided:

excessive deformations of material;

buckling;

fatigue cracks;

brittle fracture.

Accordingly, the following criteria are to be met:

ultimate strength;

buckling stress;

fatigue strength.

2.4.1.3 To prevent brittle fracture of structural elements, the choice of materials, the design of structural details and welding are to comply with the requirements of 1.4 and 1.5.

Table 2.3.11.2

Combination	Common environmental loadings					
	main loading	Attendant loadings				
		ice loading	wave loading	wind loading	current loading	seismic loading
1	Extreme ice loading	—	—	Average statistical wind loading	Extreme current loading	—
2	Extreme wave loading	—	—	Average statistical wind loading	Extreme current loading	—
3	Extreme seismic loading	Average statistical ice loading	—	—	—	—
4	Extreme seismic loading	—	Average statistical wave loading	—	—	—

2.4.2 Ultimate strength criterion.

2.4.2.1 The ultimate strength criterion stipulates requirements aimed at precluding the possibility of reaching a limit state due to plastic deformations and a collapse of MODU/FOP structural element or the entire structure due to single action of the most unfavourable combination of loadings possible during service life of the unit.

2.4.2.2 The ultimate strength criterion for survival conditions (extreme impact) is determined by the expression

$$\sigma_d \leqslant \eta_1 R_d \quad (2.4.2.2)$$

where σ_p = design structural stress caused by the most unfavourable combination of loadings, MPa;
η_1 = safety factor (see 2.4.2.5);
R_d = design ield stress of material in accordance with 1.5.1.5, MPa.

2.4.2.3 Design stresses σ_d in structural elements in the survival conditions or under extreme loadings are determined from the expression:

.1 while assessing stresses in the framing sections and in the plate centre:

$$\sigma_d = \sigma_e \quad (2.4.2.3.1)$$

where $\sigma_e = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau^2}$;
σ_x, σ_y and τ = components of structural stresses in the point under consideration , each of them takes into account mutual action of global and local loadings;

.2 while assessing the stresses in a plate centre:

$$\sigma_d = \sigma_{pl} \quad (2.4.2.3.2)$$

where σ_{pl} = maximum bending stresses determined on the supporting contour under exposure of local loadings.

2.4.2.4 The ultimate strength criterion for the operating and transit conditions are determined by the following expressions:

$$\left.\begin{aligned} &\sigma_x \leqslant \eta_1 R_d, \\ &\sigma_y \leqslant \eta_1 R_d, \\ &\tau \leqslant 0{,}57\eta_1 R_d; \end{aligned}\right\} \quad (2.4.2.4\text{-}1)$$

$$\sigma_{pl} \leqslant \eta_1 R_d \quad (2.4.2.4\text{-}2)$$

where σ_x, σ_y and τ = components of structural stresses in the point under consideration , each of them takes into account mutual action of common and local loadings, MPa;
σ_{pl} = maximum bending stresses in a plate determined on the supporting contour under exposure of local loadings, MPa;
η_1 = safety factor (see 2.4.2.5);
R_d = design yield stress of material in accordance with 1.5.1.5, MPa.

2.4.2.5 The safety factors η_1 in connection with the ultimate strength criterion are not to exceed the values shown in Table 2.4.2.5.

2.4.2.6 Additional criteria of ultimate strength referring to specific type of MODU/FOP as well as explanations required for the criterion (2.4.2.3.1), (2.4.2.3.2), (2.4.2.4-1) and (2.4.2.4-2) are contained in respective paragraphs of Section 3.

2.4.3 Buckling strength criterion.

2.4.3.1 The buckling strength criterion stipulates requirements for those parameters of MODU/FOP structural elements which provide stability of the given configuration. Critical buckling strengths are those which cause a structure to pass from one form of equilibrium to another.

2.4.3.2 Buckling strength criterion is determined by the expression

$$\sigma_x \leqslant \eta_2 \sigma_{cr} \quad (2.4.3.2)$$

where σ_x = design stresses for the specified condition of the structural element, MPa;
σ_{cr} = critical buckling strength, MPa;
η_2 = safety factor.

2.4.3.3 In buckling strength calculations of compressed and bent cylindrical shells, account should be taken of geometric imperfections of shape.

2.4.3.4 Flexibility of isolated compressed elements is to be not more than:

$$\lambda = l_e/\rho \leqslant \lambda_{max} \quad (2.4.3.4)$$

where l_e = effective unsupported length of the beam, mm;
ρ = minimum radius of inertia of the sectional area, mm;
λ_{max} = maximum permissible flexibility as per Table 2.4.3.4.

2.4.3.5 While checking the buckling strength of isolated compressed elements the safety factor η_{20} is to be not more than

Table 2.4.2.5

Design conditions	Type of unit (platform)	Strength criteria	Structural elements		
			Special	Primary	Secondary
Survival or extreme loading	MODU	(2.4.2.3.1)	0,8	0,84	0,86
	TLP/FOP	(2.4.2.3.1)	0,75	0,8	0,83
	MODU	(2.4.2.3.2)	1,3	1,4	1,5
	TLP/FOP	(2.4.2.3.2)	1,25	1,35	1,45
Operation and transit	MODU/FOP	(2.4.2.4-1)	0,55	0,6	0,7
	MODU/FOP	(2.4.2.4-2)	0,9	1,0	1,1

Table 2.4.3.4

Normative yield strength of material, R_{eH}, MPa	Maximum permissible flexibility λ_{max}
240	165
315	155
355	150
390	150
420	150
460	140
500	130

$$\eta_{20} = 0{,}67, \text{ if } \lambda \geqslant \lambda_0;$$
$$\eta_{20} = 0{,}84(1 - 0{,}2\lambda/\lambda_0), \text{ if } \lambda < \lambda_0 \qquad (2.4.3.5)$$

where $\lambda_0 = \sqrt{2\pi^2 E/R_{eH}}$;
E = Young's modulus, MPa;
R_{eH} = yield stress of material, MPa.

2.4.3.6 The safety factor η_2 of bars subjected to combined axial compression and bending is to meet the condition

$$\eta_2/\eta_{20} + \sigma_{xbend}/[\sigma] \leqslant 1 \qquad (2.4.3.6)$$

where η_{20} = safety factor according to 2.4.3.5;
σ_{xbend} = acting stress caused by bending, MPa;
$[\sigma]$ = permissible stresses, MPa, (in accordance with 2.4.2, i.e. $[\sigma] = \eta_1 R_d$).

2.4.3.7 The safety factor of plate elements exposed to system of forces on the edges, which may cause buckling, is to be determined by the formula

$$\eta_2 = \sqrt{\sum_{i=1}^{n} (\sigma_i/\sigma_{i_{cr}})^2} \qquad (2.4.3.7\text{-}1)$$

where n = number of simple forms of stresses which may be used to represent the actual loaded condition. Examples of such stresses are: compression in x and y directions; average shear stresses;
σ_i = actual stresses of the i-th form, MPa;
$\sigma_{i_{cr}}$ = critical stresses corresponding to the i-th form of stresses, MPa.

The safety factor is not to exceed the value

$$\eta_2 = 0{,}84(1 - 0{,}2R_{eH}/\sigma_e) + 0{,}06 \qquad (2.4.3.7\text{-}2)$$

where σ_e = Euler's stress corresponding to the least value of all critical buckling strengths and forms of loaded condition under consideration, MPa.

2.4.3.8 Buckling strength calculation of unstiffened tubular elements, the interrelation of common and local loss of buckling may be omitted for:

elements which are liable to bending and compression at

$$D/t \leqslant 0{,}1E/R_{eH}; \qquad (2.4.3.8\text{-}1)$$

elements which are liable to bending, compression and excessive external pressure at

$$D/t \leqslant 0{,}45\sqrt{E/R_{eH}} \qquad (2.4.3.8\text{-}2)$$

where D and t = average diameter and thickness, respectively, mm, of tubular element wall;
E = see 2.4.3.5;
R_{eH} = see 1.5.1.5.

If the above inequalities are not executed, then it is necessary to take into account interaction of local and common buckling in calculation of the tubular element buckling strength. Applied methods of calculation are to be agreed with the Register.

2.4.3.9 Register may consider possibility of loosing stability of the horizontal plates of primary and secondary structural elements. In such case methods of calculation and permissible stresses are to be justified and agreed with the Register.

2.4.4 Fatigue strength criterion.

2.4.4.1 The fatigue strength criterion stipulates requirements aimed at preventing the origination of dangerous, by possible consequences, fatigue damage during service life of the structure which is caused by unsteady change of operating loadings of different magnitude.

2.4.4.2 Calculation of the fatigue strength is made for critical points which list is agreed by the designer with the Register.

2.4.4.3 Designing of the platform structures should be made on the basis of the "safe damage" criterion which implies that fatigue criterion is oriented at the stage of initiation of fatigue macrocrack rather than the stage of crack development. Crack initiation criterion is based on the hypothesis of linear damage summation shown by the expression

$$\sum_{i=1}^{i=K} n_i/N_i \leqslant \eta \qquad (2.4.4.3)$$

where n_i = the number of stress cycles at the i-th level of loading;
N_i = number of stress cycles prior to appearance of the crack at the i-th level of loading;
K = number of loading levels considered;
η = permissible limit level of relative vulnerability.

2.4.4.4 Permissible limit level of relative vulnerability η depends on the class of the structural element (see 1.4), category of joint within the class of responsibility, degree of access for examination and repair. The class of the structural element and category of the joint are assigned by the designer upon agreement with the Register.

2.4.4.5 Parameter η represents a product of

$$\eta = \beta_1\beta_2,$$

β_1 and β_2 values are given in Tables 2.4.4.5-1 and 2.4.4.5-2.

2.4.4.6 The source of cyclical loadings is waves, wind, current, ice, seismicity reason, vibration of machinery. The initial data for each type of cyclical loadings is recurrence of environmental conditions (see 2.2.1 to 2.2.6).

Table 2.4.4.5-1

β_1 coefficient

Class of the structural element	Category of joint under consideration	
	I	II
Special	0,8	0,6
Primary	0,9	0,8
Secondary	1,0	1,0

Table 2.4.4.5-2

β_2 coefficient

Access during examination and repair		
No access	Hard-to-reach	Good access
0,5	0,75	1,0

2.4.4.7 Service life is recommended to be determined by the following formula:

self-elevating units

$$T_p = N_y\sigma_y^m \Big/ \sum_i \sum_j \sum_k \frac{p_{ijk}\Gamma(1+m/K_{ijk})(1+\beta_{ijk})a_{\upsilon_{ijk}}^m}{T_{e_{ijk}}} \qquad (2.4.4.7\text{-}1)$$

where N_y, σ_y, m = parameters of fatigue curve;
δ_f = fatigue limit based on N_f cycles;
m = slope of fatigue curve in coordinates $\lg\delta - \lg N$.
$T_{e_{ijk}}$ = effective period of the process of wave loadings at ij-th stationary conditions, featuring i-th height of the 3 per cent probability of exceedance wave, j-th average period of waves;
p_{ijk} = recurrence of stationary conditions;
k_{ijk} and $a_{\upsilon_{ijk}}$ parameters of form and scale of the stress distribution, respectively (see 3.1.4.9);
$\beta_{ijk} = a_{w_{ij}}/a_{\upsilon_{ij}}$ (see 3.1.3.6, 3.1.4.9);
$\Gamma(\cdot)$ = gamma function;

semi-submersible units

$$T_p = N_y\sigma_y^m \Big/ \sum_i \sum_j \sum_k \frac{p_{ijk}2^{m/2}\Gamma(1+m/2)\sigma_{\upsilon_{ijk}}^m}{T_{e_{ijk}}} \qquad (2.4.4.7\text{-}2)$$

where $\sigma_{\upsilon_{ijk}}$ = standard deviation of the stress process at the ijk-th stationary wave conditions.

TLP/FOP fatigue life at wave, seismic or variable ice loadings is recommended to determine on the basis of the analytical dependency

$$T_p = N_y\sigma_y^m \Big/ \sum_i \frac{p_i\Gamma(1+m/K_i)a_i^m}{T_{e_i}\sigma_y^m} \qquad (2.4.4.7\text{-}3)$$

where T_{e_i} = effective period of i-th process;
a_i and K_i = parameters of scale and form of the i-th process (see 3.3.2.1.4, 3.3.2.4.4, 3.3.2.3.3, 3.3.2.3.5) ;
N_y, σ_y, m = parameters of fatigue curve; σ_y = fatigue limit on the basis of N_y cycles;
m = slope of fatigue curve in coordinates $\lg\sigma$ — $\lg N$.

2.4.4.8 To assess preliminarily the risk of origination of fatigue damage and to determine the main scantlings of hull structures it is recommended to use the Register modified fatigue curves as fatigue curves (Figs. 2.4.4.8-1 and 2.4.4.8-2) in accordance with the international classification of structural types of nodes and joints (classes B, C, D, E, F, F2, G, W and T).

2.4.4.9 Fatigue curves are applicable to 22 mm materials for flat structures and 32 mm for tubular structures. Fatigue limit for the given thickness of elements differing from the basic ones is determined by the formula

$$\sigma_y^+ = \sigma_y(t_B/t)^{1/4} \qquad (2.4.4.9)$$

where t_B = basic thickness;
t = real thickness.

2.4.4.10 The design stress range for base metal in calculations of fatigue curves as on Fig. 2.4.4.8-1 and

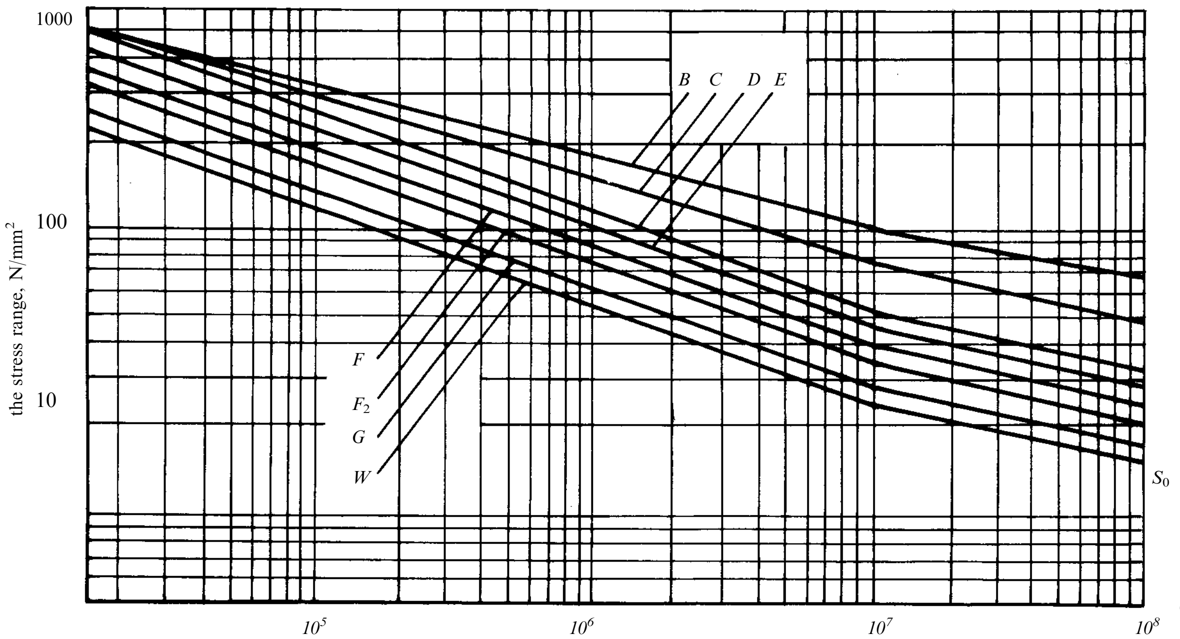


Fig. 2.4.4.8-1 Fatigue curves

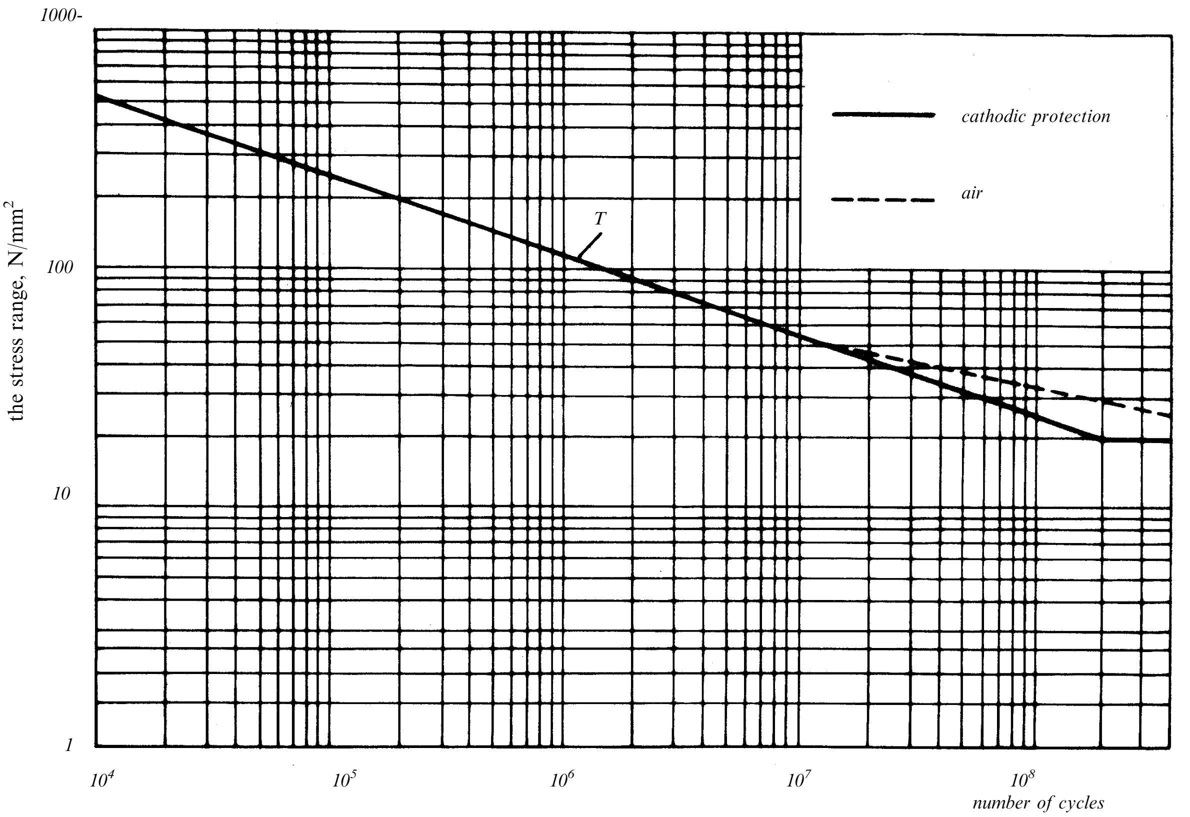


Fig. 2.4.4.8-2 S-N curves for tubular joints

2.4.4.8-2 may be reduced depending on the mark of average stresses. Reduction coefficient μ which reduces the stress range is shown in Fig. 2.4.4.10.

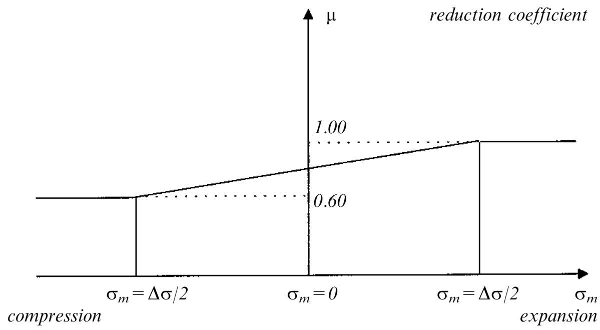


Fig. 2.4.4.10 The stress range for S-N curves. The base metal

2.4.4.11 The service life of the structure T_{ser} is defined by the customer. Design service life T_d of structures is to be $T_d \geqslant 1{,}1T_{ser}$.

2.4.4.12 Where the obtained results of the service life assessments made in accordance with 2.4.4.8 to 2.4.4.10 suggest that the origination of premature fatigue fractures in welded joints of the structure types used is possible, it is necessary to made more detailed calculations of fatigue strength of the welded joints using methods approved by the Register, which take into account the main design and technological factors and define fatigue serviceability of welded joints. It is also necessary to choose an appropriate implementation of the welded joints and hull assemblies which ensure the required design service life accounting for the use of special technological methods for enhancing the fatigue strength of the joints in accordance with 2.8.7, Part XIII «Welding» of MODU/FOP Rules.

2.5 STRENGTH CALCULATION PROVISIONS

2.5.1 General.

2.5.1.1 Strength calculations are divided into the following stages:

evaluation of values, characteristics and distribution of design common and local loadings, their combination for the given operating conditions;

evaluation of stresses caused by the common and local loadings, adding of stresses;

evaluation of design stresses or evaluation of ultimate loadings;

comparison of design values versus requirements of MODU/FOP Rules.

All major parts of the calculation are equally important, the same requirements are put to their accuracy and justification as to the whole calculation.

2.5.1.2 Calculations are to be made following the recognized methods. Provisions of the Rules for the Classification and Construction of Sea-Going Ships are to be used if applicable.

2.5.1.3 Idealized structural model is to reflect peculiarities of structure: mutual location and geometry of primary carrying members, section geometrical characteristics. Meanwhile, the idealized structural models are to be subdivided into subsystems of various levels.

Requirements to the design models are set forth in 2.5.2 to 2.5.5 of the present Section and Appendix 2.

2.5.1.4 It is allowed not to consider stress components which value is less than 10 per cent of design yield strength of material while making calculation of the structural elements which are exposed to multicomponent stress and deformation.

2.5.1.5 Additional provisions on strength calculations referred to MODU/FOP of specific type are contained in respective paragraphs of Section 3.

2.5.2 Evaluation of common stresses.

2.5.2.1 MODU/FOP structural models keeping due note of their macropeculiarities are to be developed in order to evaluate common stresses (or stresses caused by common loadings) which relate to common structural deformations. Usually, calculation of the structural stress and deformation is performed on the basis of single calculation scheme, i.e. it is recommended to consider the structure as a whole.

Use of simplified calculation schemes (for parts of structures) is allowed if their use is justified. In any case the model is to be detailed as far as it is necessary for evaluation of common stresses.

2.5.2.2 Calculation of MODU/FOP stresses and deformations is generally recommended to perform following the finite element method on the basis of the beam, plate and beam-and-plate idealization.

2.5.2.3 MODU/FOP strength calculation is to take into account the interaction of the structure with the seabed. While modelling of the "structure-seabed" system, the latter may be represented by reactive forces or elastic springs in the finite element nodes which generally resist to vertical and horizontal shifts.

2.5.2.4 If buckling is allowed under compression forces (see 2.4.3.9), it is necessary to reduce flexible members (plates) according to the following scheme:

0,25 of the shorter side of the plate supporting contour adjoining the longitudinal and transverse beams on both sides are not liable to reduction;

residual (reduced) part of plate is used in calculations with the reduction coefficients

$$\varphi_1 = \sigma_{x,cr}/\sigma_x,\ \varphi_2 = \sigma_{y,cr}/\sigma_y \qquad (2.5.2.4)$$

where σ_x, σ_y = general compressing stresses which act in rigid members (absolute values) in the longitudinal and transverse directions respectively;

$\sigma_{x,cr}$, $\sigma_{y,cr}$ = critical stresses in flexible members which cause buckling if they act simultaneously.

After reduction of flexible members, the design compression stresses acting in rigid members are to be determined in the second approximation. If the second approximation of stresses differs from the stresses of the first approximation by less than 5 per cent, no more refinement is needed. Otherwise, the third and further approximations are needed.

2.5.3 Girder system calculation.

2.5.3.1 In general case, calculation of the girder system (grillage, frame) or its separate elements is to be based on the calculation scheme which takes into account interrelation of neighboring structural elements.

The beam, plate and beam-and-plate models may be used for the grillage calculation. Simplified calculation schemes may be used if it is justified.

2.5.3.2 Section moduluses and moments of inertia of frames during calculation are to be determined taking account of effective flange, which thickness is taken equal to its average thickness in the beam cross section under consideration.

The width of the effective flange b_{fl} of stiffeners is taken equal to the least of the following values determined by the formula

$$b_{fl} = l/6; \qquad (2.5.3.2\text{-}1)$$

$$b_{fl} = 0{,}5(b_1 + b_2) \qquad (2.5.3.2\text{-}2)$$

where l = considered frame span between supports, m;

b_1, b_2 = distance of the considered frame from the nearest frames of the same direction which are located on both sides of the considered frame, m.

The width of the effective flange of ends is determined by the formula

$$b_{fl} = kb \qquad (2.5.3.2\text{-}3)$$

where k = coefficient taken from Table 2.5.3.2 in relation to b, the given length of the frame span l_{sp} and number of frames n supported by the deep member in question.

Table 2.5.3.2

n	l_{sp}/b						
	1	2	3	4	5	6	7 and more
⩾6	0,38	0,62	0,79	0,88	0,94	0,98	1,0
⩽3	0,21	0,40	0,53	0,64	0,72	0,78	0,80

N o t e: For intermediate values of l_{sp}/b and n, coefficient k is determined by means of the linear interpolation.

For simply supported ends the given span $l_{sp} = l$, and for clamped ends $l_{sp} = 0{,}6l$. The way in which the framing members are to be supported (fixing or simply supported) is determined on the basis of general engineering principles proceeding from the actual structure (brackets, welding of webs, face plates etc) and it is characterized by presence or absence of bending moment effects in the span point of the member.

2.5.3.3 Transverse section area of stiffeners or girders taking up axial forces is to be determined taking into account effective flange which width is equal to half-sum of distance of the frame in question from the nearest frames of the same direction which are located on both sides.

2.5.3.4 The area of the web cross section is to be determined keeping due note of cut-outs in the design section (net section).

2.5.3.5 Usually, sections with the maximum normal, shear stresses or their combination are taken for design sections. Summation of stresses caused by common and local loadings is to be carried in order to meet strength criteria (2.4.2.3.1) and (2.4.2.4-1).

2.5.4 Calculation of plates.

Calculation of plating is based on the assumption that they are clamped ends. Usually, design loading is treated as equally distributed over the plate.

On the basis of this assumption the bending normal stresses are determined in the middle part of the plate which are summed with the common structural stresses in order to meet strength criterion (2.4.2.3.1) and maximal bending stresses on the supporting contour in order to meet strength criteria (2.4.2.3.2) and (2.4.2.4-2).

2.5.5 Buckling strength of structural elements.

2.5.5.1 Buckling strength calculations are made to meet 2.4.3 criteria. It is recommended to use calculation scheme taking into account interrelation of adjacent structural elements for calculation of structural elements buckling strength. Otherwise, the structural element (girder, frame element, plate etc.) is to be treated as simply supported along the contour.

2.5.5.2 It is necessary to consider deviation from the Huge's law to determine critical stresses. In such case the critical normal stresses σ_{cr} are determined by the formula

$$\sigma_{cr} = \sigma_e \text{ at } \sigma_e \leqslant 0{,}6R_{eH}; \qquad (2.5.5.2\text{-}1)$$

$$\sigma_{cr} = R_{eH}(1{,}113 - 0{,}32R_{eH}/\sigma_e) \quad \text{at } 0{,}6R_{eH} < \sigma_e < 2{,}4R_{eH}; \qquad (2.5.5.2\text{-}2)$$

$$\sigma_{cr} = R_{eH} \text{ at } \sigma_e \geqslant 2{,}4R_{eH}, \qquad (2.5.5.2\text{-}3)$$

where σ_e = the Euler normal stress, MPa.

Steel yield strength for shear stresses is $\tau_T = 0{,}57R_{eH}$ when the value of the tangential stresses is determined.

2.5.5.3 Provisioning of the local stability of the framing elements (webs, flange), local strengthening should be carried out in accordance with the Rules for the Classificiation and Constrcution of Sea-Going Ships.

2.5.6 Helideck strength calculation.

2.5.6.1 Loads.

Dimensions of helideck members and its supporting structures are to be determined at permissible stresses as per 2.5.6.2 of the present part on the basis of the following design loadings:

equally distributed loading over the whole area of helideck — at least 2 kN/m^2;

impact loading (caused by helicopter landing) — at least 75 per cent of the maximum helicopter takeoff weight applied to each of two spots of helicopter wheels which area is 0,3 x 0,3 m^2; if the upper deck of the habitable superstructure or wheelhouse is used as a helideck then the said impact loading is to be increased by 15 per cent;

arrangement of helicopters; if MODU/FOP operation implies permanent arrangement of helicopter on the helideck then the loading is determined as a maximum loading recommended by the wheel supplier multipled by the dynamic coefficient which is conditioned by the MODU rolling.

In addition to the above the equally distributed loading of at least 0,5 kN/m^2 in case of snow or icing is to be taken into account.

2.5.6.2 Permissible stresses.

Stresses permissible for the helideck are assigned in accordance with Table 2.5.6.2 keeping due note of the loading in question.

Table 2.5.6.2

Loading	Permissible stresses		
	Plating	Longitudinal underdeck girders	Frames, legs etc.
Equally distributed	$0{,}6R_{eH}$	$0{,}6R_{eH}$	$0{,}6R_{eH}$[2]
Impact loading from helicopter landing	[1]	$1{,}0R_{eH}$	$0{,}9R_{eH}$[2]
Arrangement of helicopters	R_{eH}	$0{,}9R_{eH}$	$0{,}8R_{eH}$[2]

[1]To be assigned upon agreement with the Register depending on the choice of the calculation method.

[2]For elements subjected to axial compression, yield strength or critical stresses are to be treated as permissible whichever is the least.

3 STRENGTH ISSUES SPECIFIC TO PLATFORMS

3.1 SELF-ELEVATING UNITS

3.1.1 General.

3.1.1.1 The structural strength of self-elevating units is to be tested, on the basis of criteria mentioned under 2.4, for five design conditions:

survival;

operation;

transit;

positioning on location;

removal from location.

For positioning on location and removal from location (preloading and pulling out of legs), the safety factors and strength criteria should be chosen as for the survival condition.

3.1.1.2 A self-elevating unit is to have a clearance, in m, not less than:

$$h_c \geqslant 0{,}6h_{50} + \Delta h_{50} + 1{,}50 \qquad (3.1.1.2)$$

where h_{50} = extreme wave height, in m, (once in 50 years) for the sea area in question;
Δ_{50} = extreme tide, in m, for the basin (once in 50 years).

3.1.1.3 When a self-elevating unit is prepared for a transit condition to last a day or more, the helicopter deck height H, in m, above the calm waterline is to be determined by the formula

$$H = 1{,}8 \cdot 10^{-3} q^{2{,}5} + 3(x/q) + 2(h_{50}/12 - 1) + 1{,}2(\tau - 1)^{0{,}7} \qquad (3.1.1.3)$$

where $q = \sqrt[3]{\Delta}$;
Δ = cubic displacement, in m^3, of a MODU in transit;
x = distance, in m, from the farthest edge of helicopter deck to the centre-of-graviti position of a MODU, as measured along the hull length;
h_{50} = height, in m, of the wave occurring with the periodicity once in 50 years;
τ = voyage duration, in days, not exceeding four.

3.1.1.4 Wind, wave and seismic loads are to be determined for the most unfavourable angles of wave propagation and wind attack.

3.1.1.5 When making the dynamic strength analysis of a self-elevating unit, the lowest natural frequency (s^{-1}) of bending vibrations is to be determined by the formula

$$p = \sqrt{\frac{12 n_k E J_k (1 - G_p / n_k P_e) g}{l^3 (4 - 3)(G_p + 0{,}5 n_k G_k)}}\,\eta_d \qquad (3.1.1.5)$$

where n_k = leg number;
E = elastic modulus, in kPa, of leg material;
J_k = equivalent moment of inertia, in m^4, of a leg cross — sectional area with regard to the principal centroidal axis (see 3.1.2.3);
G_p = pontoon mass, in kN;
G_k = one leg mass, in kN;
$P_e = \frac{\pi^2 E J_k}{4 l^2}(3æ + 1)$ = Euler load, in kN, upon a leg as a part of a space frame;
g = gravity acceleration, in m/s^2;
l = design leg length, in m, equal to the distance between the leg footing and a point located at half the distance between the horizontal supports of a pontoon;
= supporting pair factor, see 3.1.2.2;
η_d = correction factor accounting for the effect of leg securing in a pontoon, see 3.1.2.4.

3.1.2 Design structural diagram of a self-elevating unit.

3.1.2.1 For assessing the stressed condition, idealization of structures on several levels is used (see Fig. 3.1.2.1):

structural frame ("superelement");

leg section under consideration.

3.1.2.2 The leg-seabed interaction is accounted for by the supporting pair factor which characterizes the degree of leg embedment with regard to the leg turning in the seabed. In the case of leg bending by low-frequency pattern, the value of will depend on the leg parameters and seabed, as described by the formula

$$æ = 1/(1 + AEJ_k/l) \qquad (3.1.2.2)$$

where A = coefficient of proportionality between the supporting moment and the turning angle of the footing;
for E, l, J_k see 3.1.1.5.

3.1.2.3 The moment of inertia J_k of the surface area of a truss-type leg can be referred to the moment of inertia of an ideal section of all the longitudinal elements forming the leg as:

$$J_k = J_u/\mu \qquad (3.1.2.3)$$

where J_u = moment of inertia, in m^4, of an ideal section;
μ = reduced rigidity characteristic depending on the type of structural module, geometrical characteristics of its elements and relative leg length.

3.1.2.4 The correction factor η_d depends on the distance d, m, between the lower and upper horizontal supports, on the correlation between the bend and shift rigidity of the leg (where B is leg breadth, m), on the degree of leg embedment in the seabed (see Fig. 3.1.2.4).

In the case of a non-typical installation of the lifting mechanism (without dampers, for instance), a special analysis of the area where the leg is fitted in the hole may be submitted to the Register for homologation with a correction of vibration frequences and with load redistribution among mechanisms and supports.

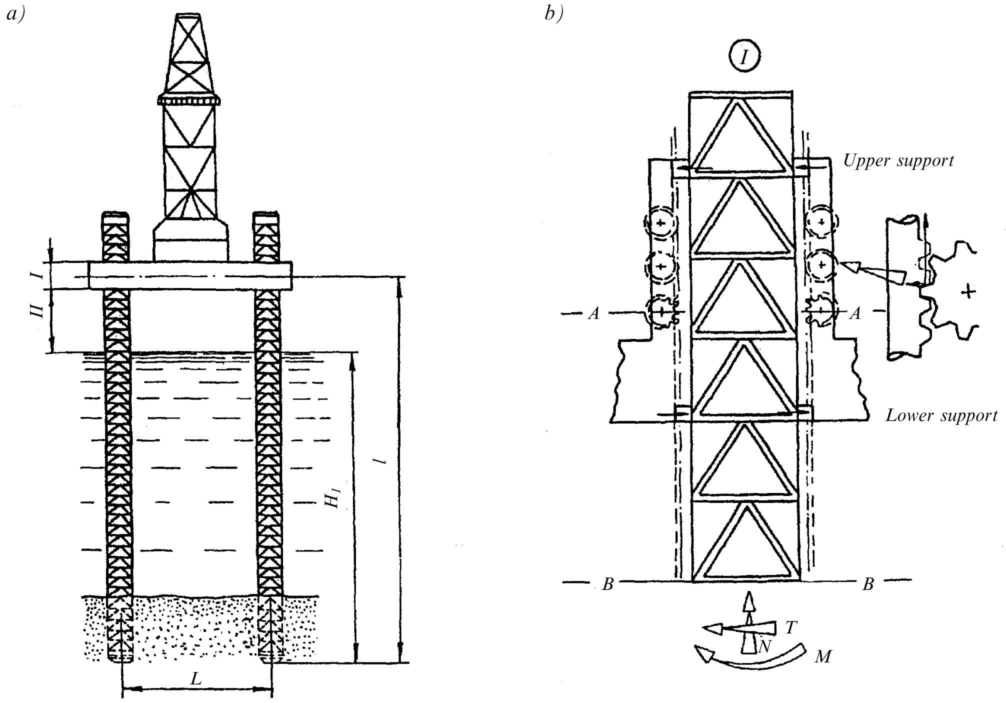


Fig. 3.1.2.1 Idealization of self-elevating unit structures of different levels:
a) Structural frame ("superelement"), b) Leg section (I) under consideration

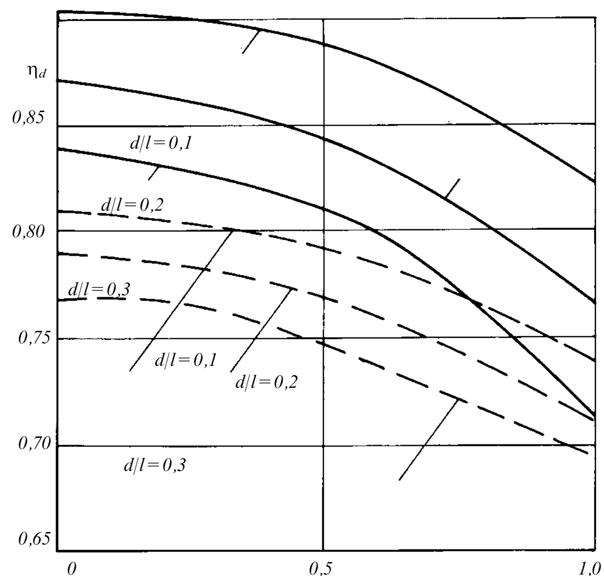


Fig. 3.1.2.4 Correlation between the correction factor η_d and the parameters , d/l, B/l
——— $B/l = 0,1$ — — $B/l = 0,2$

3.1.2.5 The flexibility coefficients A are to be determined by the formulas:

for vertical vibrations —

$$A = (1-\nu)/4Gr_0; \qquad (3.1.2.5\text{-}1)$$

for horizontal vibrations —

$$A = (2-\nu)/8Gr_0; \qquad (3.1.2.5\text{-}2)$$

for rotational vibrations —

$$A = 3(1-\nu)/8Gr_0^3; \qquad (3.1.2.5\text{-}3)$$

for torsional vibrations —

$$A = 3/16Gr_0^3. \qquad (3.1.2.5\text{-}4)$$

where G = seabed shift modulus, MPa;
ν = Poisson's ratio;
r_0 = foundation radius, m.

Where the foundation is rectangular with the sides $B \times L$, an equivalent radius is to be introduced, as follows:

$r_0 = \sqrt{BL/\pi}$ for vertical and horizontal vibrations;

$r_0 = \sqrt[4]{BL^3/3\pi}$ for rotational vibrations around the horizontal axis,

$r_0 = \sqrt[4]{BL(B^2+L^2)/\pi}$ for torsional vibrations.

For embedded legs whose friction layer lies at some depth, the flexibility coefficient for rotational vibrations is to be determined by the formula

$$A = 3(1-\nu)/16Gr_0^3\,. \qquad (3.1.2.5\text{-}5)$$

3.1.2.6 The legs' most loaded area is located within the upper and lower rails, where the loads from columns are transmitted to the hull.

The bending moment in this area is partially formed by horizontal forces from guides, partially by vertical forces of the lifting mechanism. Relative contribution of vertical M_v and horizontal M_h forces is determined by the parameter β:

$\beta = M_v/(M_v + M_h)$. (3.1.2.6-1)

During total strength analysis the hull stiffness may be generally accepted infinitely large in comparison with the column stiffness. The leg mechanism is presented by rotation spring with rotational stiffness K_m. In this case the parameter β is to be determined by the formula

$$\beta = \frac{1}{1 + \Delta_{z_g} GF_c/K_m} \ , \qquad (3.1.2.6\text{-}2)$$

where G = shear modulus of the column material;
F_c = shearing area of the column, m²;
Δz_g = distance between the upper and lower guides, m;

$$K_M = \frac{1}{2} Kb^2 \qquad (3.1.2.6\text{-}3)$$

where $K_m = \dfrac{1}{1/K_{bend} + 1/K_{shear}}$
K_{bend} = ending stiffness of the column;
K_{shear} = shear stiffness of the column.

3.1.3 Wind loads.

3.1.3.1 Wind loads are to be determined by the Formula (2.3.8).

3.1.3.2 It is recommended that the dynamics of wind load application be considered beginning from the period of natural bending vibrations of the first mode $\tau = 130/\overline{w}_{10}$, in s.

In this case, the amplification factor K_w is to be used proceeding from Fig. 3.1.3.2 in which

$$\nu_w = \omega_{max}/p \qquad (3.1.3.2)$$

where $\omega_{max} = 4 \cdot 10^{-3}\overline{w}_{10}$ is the modal frequency of spectral density of wind pulsation;
p = natural bending vibration frequency of a self-elevating unit;
δ_w/π = relative vibration decrement of self-elevating unit.

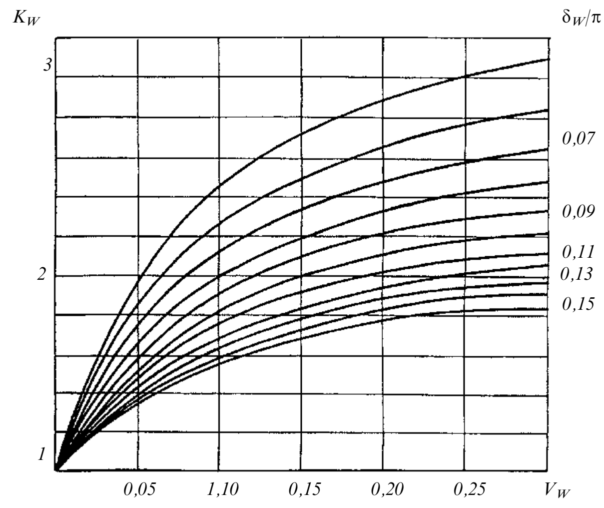


Fig. 3.1.3.2 Amplification factor of wind loads

3.1.3.3 When considering the pulse component of wind loads, the nonsynchronous character of their effect is to be accounted for by using the factor $\eta = 0{,}8$.

3.1.3.4 For each stationary mode, the values of internal forces of proportional wind actions are to be determined:

for a four-legged self-elevating unit —

$\overline{M_w} = 0{,}09\overline{Q_w}\, l(2 - æ)$, is the bending moment,

$\overline{T_w} = 0{,}18\overline{Q_w}$, is the shearing force, (3.1.3.4-1)

$\overline{N_w} = 0{,}18\overline{Q_w}\, \dfrac{l}{L}(2 - æ)$, is the axial force;

for a three-legged self-elevating unit —

$\overline{M_w} = 0{,}165\overline{Q_w}\, l(2 - æ)$, is the bending moment,

$\overline{T_w} = 0{,}33\overline{Q_w}$, is the shearing force, (3.1.3.4-2)

$\overline{N_w} = 0{,}58\overline{Q_w}\, \dfrac{l}{L}(2 - æ)$ is the axial force

where $\overline{Q_w}$ = the value for $w_{10} = \overline{w}_{10}$, see the Formula (2.3.8);
L = the clear spacing between legs, see Fig. 3.1.2.1.

3.1.3.5 For each stationary mode, standard deviations of the components of internal wind pulsation forces are to be determined:

for four-legged self-elevating units —

$\sigma_M^w = 0{,}18\overline{Q_w}\eta l(2 - æ)\vartheta_w K_w$;

$\sigma_T^w = 0{,}36\overline{Q_w}\eta\vartheta_w K_w$; (3.1.3.5-1)

$\sigma_N^w = 0{,}36\overline{Q_w}\eta\, \dfrac{l}{L}(2 - æ)\vartheta_w K_w$;

for three-legged self-elevating units —

$\sigma_M^w = 0{,}33\overline{Q_w}\eta l(2 - æ)\vartheta_w K_w$;

$\sigma_T^w = 0{,}66\overline{Q_w}\eta\vartheta_w K_w$; (3.1.3.5-2)

$\sigma_N^w = 1{,}15\overline{Q_w}\eta\, \dfrac{l}{L}(2 - æ)\vartheta_w K_w$

where ϑ_w = wind pulsation variability coefficient, equal to $\vartheta_w = 2{,}45\sqrt{K_{fr}}$;
K_{fr} = front resistance coefficient of underlying surface, see Table 2.2.2.

3.1.3.6 The scale parameter a_w of internal forces due to wind is assessed as:

$$a_w = 0{,}85\sigma_w. \qquad (3.1.3.6)$$

3.1.4 Wave loads.

3.1.4.1 Wave loads on leg elements of self-elevating units are to be determined in accordance with 2.3.9.1. For round and rectangular sections, the values of the inertia coefficient C_{in} and speed resistance coefficient C_{sp} are not to be less than those to be found in Fig. 3.1.4.1. When rack is available, the resistance coefficient C_{drag}^p is to be determined by the formula

$$C_{drag}^p = C_{sp} + 4\,\frac{a + b/2}{D} \qquad (3.1.4.1)$$

where D = bore diameter;
a = tooth root height;
b = rack tooth height.

For more complex shapes, the estimated values of the C_{in} and C_{sr} coefficients are to be specially agreed with the Register.

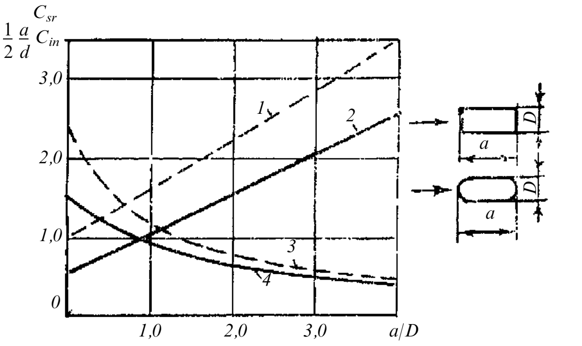


Fig. 3.1.4.1 Speed resistance coefficient C_{sr} (3,4) and inertia resistance coefficient C_{in} (1,2) for sections:
——— elliptical sections (round sections where $a/D = 1$);
– – – – – rectangular sections

3.1.4.2 When determining the wave loads, the effect of marine growth on the structure is to be considered which manifests itself in the increase of scantlings and the values of C_{in} and C_{sr} coefficients as compared to those given.

3.1.4.3 The dynamic character of wave load application is to be assessed by means of curves given in Fig. 3.1.4.3 where $\overline{\varpi}$ is the average period of surface waves, p is the natural bending vibration frequency, δ/π is the relative decrement of vibrations.

3.1.4.4 The hydrodynamic loads on the leg module consisting of a combination of vertical, horizontal and inclined members are to be determined by memberwise summation of hydrodynamic loads with due regard for the spacing of members, which is equivalent to introducing factors to account for wave load influence upon the horizontal and inclined members μ_{sr} and μ_{in}

$$\mu_{sr} = 1 + \frac{\sum_{i=1}^{n_\Sigma} n_i d_i l_i C^i_{sp}(\theta_i)\cos^2\theta_i}{n_B d_B \Delta z C^{в}_{sp}}; \qquad (3.1.4.4\text{-}1)$$

$$\mu_{in} = 1 + \frac{\sum_{i=1}^{n_\Sigma} n_i d_i^2 l_i C^i_{in}(\theta_i)\cos\theta_i}{n_B d_B \Delta z C^{в}_{in}} \qquad (3.1.4.4\text{-}2)$$

where d_B = transverse dimension, in m, of vertical batten;
n_Σ = total number of horizontal and inclined members;
d_i, l_i = diameter and length, in m, of inclined and horizontal members, respectively;
Δz = module height, in m;
θi = angle, in deg., formed by an inclined member and a plane perpendicular to the direction of wave propagation;
C^B_{sp}, C^B_{in} = speed and inertia resistance coefficients of vertical members (bearing battens);
C^i_{sp}, C^i_{in} = speed and inertia resistance coefficients of inclined and horizontal members.

The values of C^B_{sr}, C^B_{in}, μ_{sr}, μ_{in} are to be determined for the design course angle $\varphi_{des.}$ in accordance with (3.1.4.6).

3.1.4.5 For the purpose of wave load calculations, there may be omitted:

inertia component where

$$h_3 \geqslant 8{,}5 d_B C^B_{in'} \cdot \overline{u_{in'}} / C^B_{sr} \mu_{sr} \overline{u_{sr}}; \qquad (3.1.4.5\text{-}1)$$

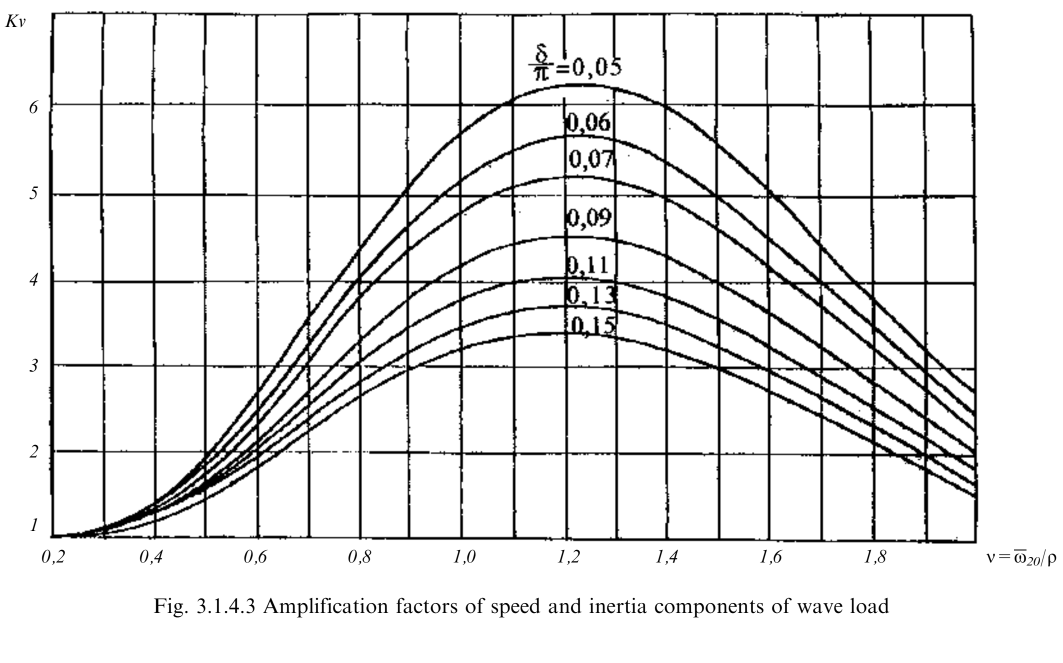


Fig. 3.1.4.3 Amplification factors of speed and inertia components of wave load

speed component where

$$h_3 \leqslant 2{,}1 d_B C^B_{in'} \cdot \overline{u_{in'}} / C^B_{sr}\, \mu_{sr} \overline{u_{sr}} \qquad (3.1.4.5\text{-}2)$$

where $\overline{u_{in}}$ and $\overline{u_{sr}}$ = form ordinate values of leg vibrations of a selfelevating unit on the level of the applicate of wave pressure resultants corresponding to the inertia and speed components:
$\overline{u_{in}} = \overline{u}$ if $z = z_{in} = H_1(1-\phi)$;
$\overline{u_{sr}} = \overline{u}$ if $z = z_{sr} = H_1(1-\phi/2)$;

$$\overline{u} = \frac{6(1-)z}{4-3\ \ l} + \frac{3}{4-3}(z/l)^2 - \frac{2}{4-3}(z/l)^3;$$

z = to be measured from the footing upwards, in m;
$\overline{\omega}_0$ = average frequency of surface waves;
$\phi = g/H_1\omega_0^2$;
H_1 distance, in m, from leg footing to calm water level.

3.1.4.6 The stressed condition of structures of a self-elevating unit is to be assessed for the most unfavourable course angles denoted later as design angles. The design course angles φ_{des} are to be assessed on the basis of the following formulas:

for four-legged self-elevating units —

$$\varphi_{des} = \frac{\pi}{4}(2i-1),\ i = 1, 2, 3, 4; \qquad (3.1.4.6\text{-}1)$$

for three-legged self-elevating units —

$$\varphi_{des} = \frac{\pi}{3}(2i-1),\ i = 1, 2, 3 \qquad (3.1.4.6\text{-}2)$$

where i = direction number.

3.1.4.7 The standard values of speed components of wave loads for design course angles are to be determined on the basis of the following dependences:

for four-legged units —

$$\sigma^{sr}_M = 0{,}35\overline{u_{sr}}\ \sigma^{sr}_Q\ K_\nu\, l(2-æ)\gamma_4;$$

$$\sigma^{sr}_T = 0{,}70\overline{u_{sr}}\ \sigma^{sr}_Q\ K_\nu\gamma_4; \qquad (3.1.4.7\text{-}1)$$

$$\sigma^{sr}_N = 0{,}70\overline{u_{sr}}\ \sigma^{sr}_Q\ K_\nu\, l/L(2-æ)\gamma_4;$$

for three-legged units —

$$\sigma^{sr}_M = 0{,}5\overline{u_{sr}}\ \sigma^{sr}_Q\ K_\nu\, l(2-æ)\gamma_3;$$

$$\sigma^{sr}_T = \overline{u_{sr}}\ \sigma^{sr}_Q\ K_\nu\gamma_3; \qquad (3.1.4.7\text{-}2)$$

$$\sigma^{sr}_N = 1{,}7\overline{u_{sr}}\ \sigma^{sr}_Q\ K_\nu\, l/L(2-æ)\gamma_3$$

where $\sigma^{sr}_Q = 1{,}34\cdot10^{-2} m_k C^B_{sr}\ \mu_{sr}\ \gamma\ d_B\ h_3^2$;
m_k = number of vertical members;
K_ν = amplification factor of wave loads, to be determined from Fig. 3.1.4.3;
γ_4 and γ_3 = factors accounting for the effects of leg spacing upon wave loads;

$$\gamma_4 = \frac{1}{\sqrt{2}}\sqrt{1+\cos(\overline{\omega}^2 L_4/g)};$$

$$\gamma_3 = \frac{1}{\sqrt{2}}\sqrt{1+\cos(\overline{\omega}^2 L_3/g)};$$

$L_4 = \sqrt{2}L$;
$L_3 = (\sqrt{3}/3)L$.

3.1.4.8 The static characteristics of internal forces generated in leg structures, which are in accordance with the inertia component of wave loads for the course angles mentioned under 3.1.4.6, are to be determined by the Formulas (3.1.4.7-1) and (3.1.4.7-2), with substituting, $\overline{u_{sr}}$ for $\overline{u_{in}}$, σ^{sr}_Q for

$$\sigma^{in}_Q = 18{,}7\cdot10^{-2} m_k C^B_{in}\ \mu_{in} S h_3 \qquad (3.1.4.8)$$

where S = sectional area, in m², of vertical member contour.

3.1.4.9 The distribution parameters of the static internal forces a_{v_0} and k_0 due to wave effects in each stationary mode are to be determined on the basis of curves to be found in Fig. 3.1.4.9, *a* and *b* proceeding from the value of the relationship

$$\frac{\sigma_{in}}{\sigma_{sr}} = \frac{6{,}2\sqrt{S}\ \mu_{in} C^B_{in}\ \overline{u}_{in}}{h_3 \mu_{sr} C^B_{sr}\ \overline{u}_{sr}}. \qquad (3.1.4.9\text{-}1)$$

The parameter of $\sigma_{Q_{sr}}$ in Fig. 3.1.4.9 is to be determined on the basis of Fig. 3.1.4.13.

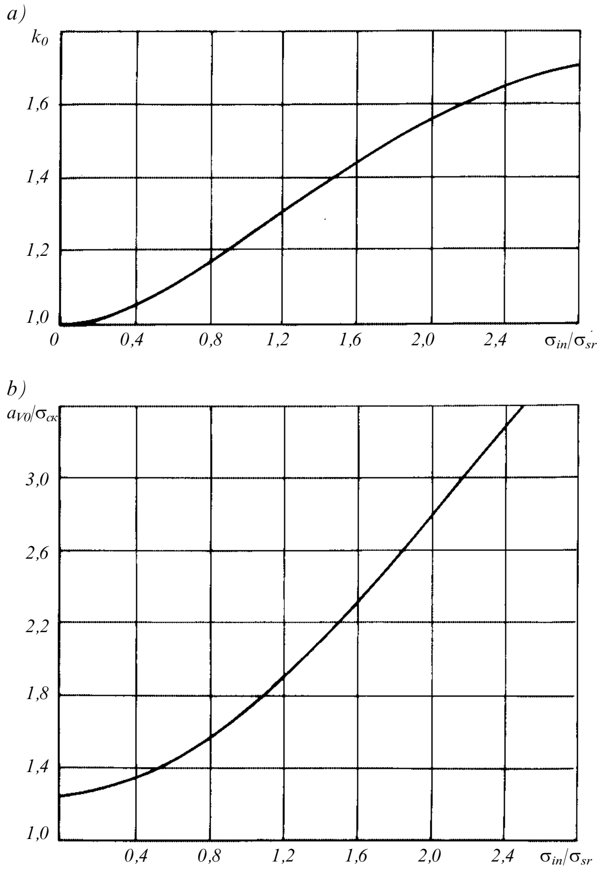


Fig. 3.1.4.9 Dependence of Weibull distribution parameters k_0 and a_{V0} on the relationship σ_{in}/σ_{sr}

Static values of a_{v_0} and k_0 are to be specified on the basis of dynamic effects by the formulas:

$$k = k_0 + \frac{(2-k_0)\nu^4}{1+(1-\nu)^4}; \qquad (3.1.4.9\text{-}2)$$

$$a_v = a_{v_0} 5^{1/k_0 - 1/k}; \qquad (3.1.4.9\text{-}3)$$

where $\nu = \overline{\omega}/p$.

3.1.4.10 For each stationary mode, the extreme values of alternating internal forces are to be determined in the design leg cross section under the combined effects of waves and wind:

$$M_{e_{ij}} = a_{v_{M_{ij}}}[\ln n_{ij}(1+\beta_{ij})]^{1/K_{ij}};\qquad (3.1.4.10\text{-}1)$$

$$T_{e_{ij}} = a_{v_{T_{ij}}}[\ln n_{ij}(1+\beta_{ij})]^{1/K_{ij}};\qquad (3.1.4.10\text{-}2)$$

$$N_{e_{ij}} = a_{v_{N_{ij}}}[\ln n_{ij}(1+\beta_{ij})]^{1/K_{ij}}\qquad (3.1.4.10\text{-}3)$$

where $a_{v_{M_{ij}}}$, $a_{v_{T_{ij}}}$, $a_{v_{N_{ij}}}$ = distribution parameters of wave bending moments, shearing and axial forces, respectively;
$\beta_{ij} = a_{w_{ij}}/a_{v_{ij}}$;
$n_{ij} = 10^8 p_{h_3\bar{\tau}}$ = volume of sample corresponding to a stationary mode occurring at regular intervals;
$n_{ij} = 10^6 p_{h_3\bar{\tau}}$ = volume of sample for the operating mode.

3.1.4.11 For each stationary mode, the values of internal forces are to be determined with due regard for the static effects of wind, pontoon weight and tide forces which are to be added to the values obtained by 3.1.4.10, namely:

$$M_\Sigma = M_e + M_p + \overline{M}_w + M_c;\qquad (3.1.4.11\text{-}1)$$

$$T_\Sigma = T_e + \overline{T}_w + T_c;\qquad (3.1.4.11\text{-}2)$$

$$N_\Sigma = N_e + N_p + \overline{N}_w + N_c\qquad (3.1.4.11\text{-}3)$$

where M_p and N_p = bending moments and axial forces due to pontoon weight, respectively;
for M_e, T_e, N_e, see 3.1.4.10;
for $\overline{M}_w$, $\overline{T}_w$, $\overline{N}_w$ see 3.1.3.4;
for M_c, T_c, N_c, see 3.1.5.

3.1.4.12 The greatest value obtained by 3.1.4.11 will be considered the design value.

3.1.4.13 In shallow water, the standard deviation of the inertia component of wave load σ_Q^{in} per leg will be determined by the formula

$$\sigma_Q^{in} = 18{,}7\cdot10^{-2} m_k C_{in}^B\ \mu_{in} S\cdot h_3\cdot th\bar{k}H\qquad (3.1.4.13)$$

where $\bar{k} = 2\pi/\bar{\lambda}$;

the standard deviation of the velocity component of wave load σ_Q^{sr} per leg will be determined from the curve in Fig. 3.1.4.13-1.

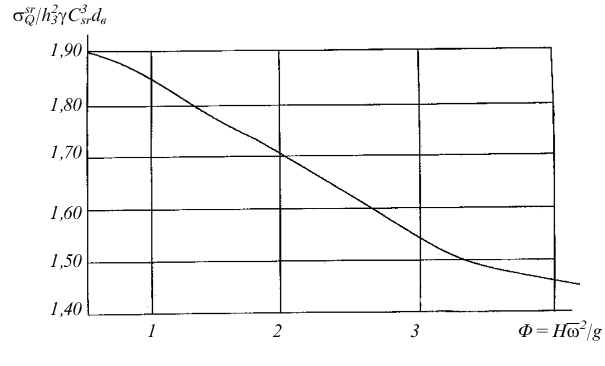


Fig. 3.1.4.13-1 Relationship between $\sigma_Q^{sr}/h_3^2\gamma C_{sr}^3 d_в$ and parameter $\Phi = H\bar{\omega}^2/g$

The applicates of the resultants Q_{sr} and Q_{in} (counting from water level) will be determined from Figs. 3.1.4.13-2 and 3.1.4.13-3, respectively.

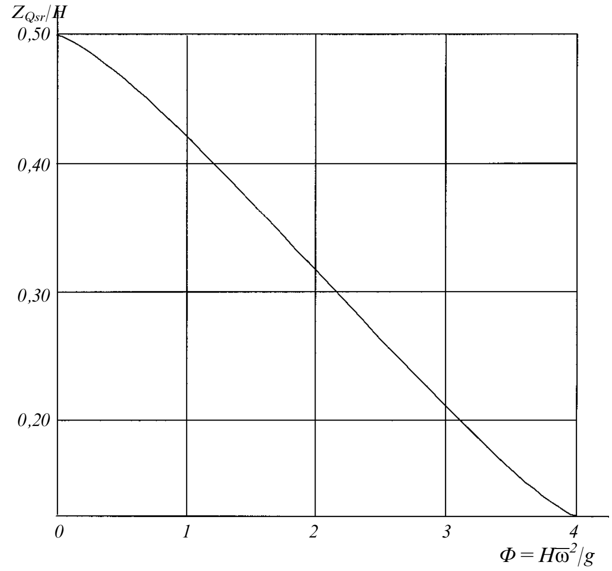


Fig. 3.1.4.13-2 Relationship between Z_{Qsr}/H and parameter $\Phi = H\bar{\omega}^2/g$

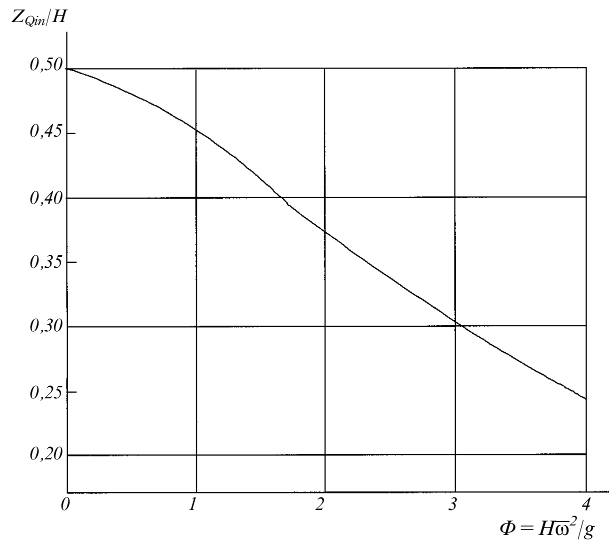


Fig.3.1.4.13-3 Relationship between Z_{Qin}/H and parameter $\Phi = H\bar{\omega}^2/g$

3.1.5 Current loads.

3.1.5.1 At an optional leg cross section, the internal forces generated by the continuous component of current will be equal to:

for a three-legged self-elevating unit ($\varphi = 60°$) —

$$M_c = (Q_T\,\bar{u}_c\,l/2)(2\,\frac{z}{l} - æ);$$

$$N_c = (2\sqrt{3}Q_c\,\bar{u}_c\,l/L)(2 - æ);\qquad (3.1.5.1\text{-}1)$$

$$T_c = Q_c\,\bar{u}_c;$$

for a four-legged self-elevating unit ($\varphi = 0°$) —

$$M_c = (\sqrt{2}Q_c\, \bar{u}_c\, l/4)(2\frac{z}{l} - æ);$$

$$N_c = (2Q_c\, \bar{u}_c\, l/L)(2 - æ); \qquad (3.1.5.1\text{-}2)$$

$$T_c = Q_c\, \bar{u}_c$$

where $Q_c = \rho C_{sr} d H_0 v_c^2/2$;
H_0 = water depth, in m;
v_c = current velocity, in m/s;
$\bar{u}_c$ = value of the u parameter (see 3.1.4.5) in section $H_1/2$.

3.1.5.2 Under the combined effect of wind and tide, an approximation is possible, as follows:

$$Q_\Sigma = Q_v + 2\sqrt{Q_v Q_c} + Q_c \qquad (3.1.5.2)$$

where Q_v = speed component of wave loads, determined in the following way

$$Q_{ск} = a_v(\ln n)^{1/K}$$

where a_v and $Q_{ск}$ = scale parameters and Weibull forms of distribution determined in accordance with diagrams to be found in Fig. 3.1.4.9.

3.1.6 Seismic loads.

3.1.6.1 In some areas, the seismic loads on a self-elevating unit can be comparable to wave loads.

The integral seismic effect on a self-elevating unit is to be determined by the formula

$$Q = M_{po}\beta_\Sigma a_{\max} \qquad (3.1.6.1)$$

where M_{po} = reduced mass of a pontoon;
a_{max} = maximum value of acceleration amplitude;
β_Σ = generalized dynamic coefficient as adopted from Fig. 3.1.6.1

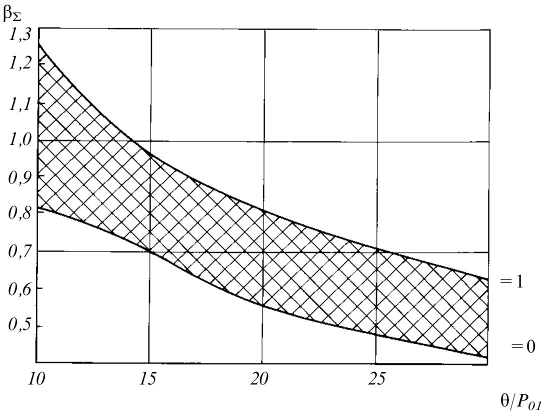


Fig. 3.1.6.1 Generalized dynamic coefficient:
θ = bearing frequency of axilogram;
P_{01} = lowest frequency of horizontal vibrations

3.1.6.2 The ultimate load Q^Σ_{ult}, which a self-elevating unit can withstand is determined by the formula

$$Q^\Sigma_{ult} = nQ^{module}_{ult}\left(1 + \frac{l}{d}\cdot\frac{2-æ}{2}\right) \qquad (3.1.6.2)$$

where n = leg number;
Q^{module}_{ult} = ultimate load upon leg module, to be determined on the basis of considering the kinematic condition of the module. For a typical truss of a self-elevating unit with K-type connections

$$Q^{module}_{ult} = 2{,}32 R_d \pi D_p t_p$$

where R_d = design yield strength, in MPa, of diagonal bracings;
D_p and t_p = diameter and thickness, in m, respectively, of diagonal bracings;
l = leg length, in m;
d = distance, in m, between the upper and lower shoulder;
æ = supporting pair coefficient (see 3.1.2.2).

3.1.6.3 Safety factor for seismic loads

in the case of earthquakes occurring once in 100 years —

$$K_a = Q^\Sigma_{ult}/Q \geqslant 1{,}25; \qquad (3.1.6.3\text{-}1)$$

in the case of earthquakes occurring once in 500 years

$$K_a = Q^\Sigma_{ult}/Q \geqslant 1. \qquad (3.1.6.3\text{-}2)$$

3.1.7 Pre-loading and pulling out of the legs.

3.1.7.1 Considerable forces may be generated in the structure of a self-elevating unit during pre-loading and pulling out of the legs. Due to this, a strength analysis of the legs and pontoon is to be carried out.

The analysis is to be aimed at:

determining the permissible levels of controlled parameters (heel and trim angles) proceeding from the conditions of leg strength;

testing the strength of pontoon structures when resting on diagonal supports in the case of a four-legged self-elevating unit, or on the basis of the deadweight with due regard for the ballast taken in the pontoon compartment in the case of a three-legged self-elevating unit.

3.1.7.2 The permissible values of heel and trim angles are to be determined on the assumption that, when pulling out the legs, the actual stresses in the most stressed points of the structure will not exceed the permissible values.

When drawing up the strength provisions, the most dangerous locations of the points of the pontoon reactions application on the leg module height, and the most stressed areas of the structure should be considered. Among these are the supporting sections of horizontal struts and bracings, as well as the midspans of vertical struts of legs.

3.1.7.3 The forces by which the interaction of leg and pontoon is manifested will be determined proceeding from the condition of ensuring concurrent movement of the pontoon and legs, and are to be characterized by heel and trim angles, as well as by the vertical axial force.

When determining unknown forces, gravity forces and the coordinates of the application point of the gravity force resultant are to be considered, as well as the floatability forces and the under-water hull shape, forces and moments generated in the supporting section of the leg as a result of interacting with the seabed.

3.1.7.4 The range of permissible values of heel and trim angles, and of the axial force will be determined proceeding from the strength conditions. These characteristics are to be considered the basic data for drawing up the service manual.

3.1.7.5 Where the axial force value is specified, the permissible values of heel and trim angles are to be determined by the procedure described in 3.1.8.3 assuming buoyancy forces to be zero and the force vector to be opposite to that of the forces generated during the pulling out.

3.1.8 Stressed condition of legs.

3.1.8.1 The leg strength analysis is aimed at determining the stressed condition of the structure where the legs are attached to the hull of the self-elevating unit and where they are embedded in the seabed.

The leg structure is to be idealized as a space frame system.

The stressed condition of leg structures is to be analyzed by methods which would make it possible to consider the peculiarities of the stressed condition of leg components, for instance, by the finite element analysis. In this case, the structure of the pontoons and of the holes for legs can be considered to be absolutely rigid.

3.1.8.2 As the leg area by which the former is attached to the hull, a leg section is to be considered which is limited from below by a cross section lying below the lower shoulder at midlength between the upper and lower shoulder, and from above it is limited by a cross section removed by 0,25*d* upwards from the uppermost point of contact with the upper shoulder, or by the end cross section of the leg (see Fig. 3.1.2.1).

3.1.8.3 As the dynamic utmost conditions for the lowest cross section of the leg area considered, the integral forces and moments are to be adopted which are determined on the simplified model of a self-elevating unit (see 3.1.2.1).

When setting up restrictions for the vertical movements within the lower section of the leg area, to be included in the dynamic utmost conditions are vertical forces transmitted to the leg by the jacking system. The value and application pattern of these forces will depend on the design of the jacking system, type of its attachment to the hull of the unit and the possibility of non-uniform distribution of these forces being prescribed to ensure the tooth strength conditions.

3.1.8.4 As a result of analysing an idealized leg construction attached to the pontoon hull, the values characterizing the movements and internal forces in the assemblies of the bar system will be determined, as well as those of response and stress distribution in the structural components.

The stress analysis for the components of the most stressed modules is to be effected through the height of three cross sections at midlength and at supporting sections.

3.1.8.5 As the embedded leg area, the leg section is to be considered whose upper side is limited by a cross section lying within 0,5*d* from the connection line of leg and footing.

For modelling the leg footing or another similar structure forming part of the lower end of the leg, an idealization is to be used to generate a plane stress in the components of the structure. Dynamic utmost conditions are to be prescribed for the upper end of the considered leg section in the same way as under 3.1.2.1. As a result of the analysis, the values of internal forces and movements are to be obtained and the stress distribution established.

3.1.8.6 Where the provisions of 3.1.8.2 to 3.1.8.5 cannot be complied with in view of principal differences from the above calculation procedure, a calculation procedure taking into account the structural peculiarities of the self-elevating unit may be submitted to the Register for homologation.

3.1.9 Loads on self-elevating unit legs during transportation.

During transportation the legs are mostly completely upturned. Combination of inertia loads during rolling or pitching together with wind load provokes extensive bending moments and axial forces in the legs as well as considerable jet forces in the portal and hull structures.

Rolling parameters may be obtained either based upon the results of model tests or calculation. One is to regard the results of rolling parameters calculation very carefully due to the non-conventional peculiarities of pontoons of self-elevating units that cause a number of non-linearities.

For the calculation in transit conditions the following is to be taken into consideration:

inertia forces corresponding to the specified amplitude of rolling or pitching with natural period of platform;

static forces corresponding to the maximum inclination of legs during rolling or pitching;

specified wind forces.

Effect of rolling, drifting or yawing is to be considered by means of introduction of the correction coefficient γ=1,2.

Rolling or pitching is assumed to be calculated with the aid of the relation:

$$\theta = \theta_0 \sin \frac{2\pi t}{T_0} \qquad (3.1.9\text{-}1)$$

where t = time, in s;
T_0 = natural period of rolling or pitching;
θ_0 = amplitude of rolling or pitching, in deg.

It is considered that the oscillation center is located within the water line level.

Acceleration of lumped masses at the distance r, in m, from the oscillation center, in m/s^2 is determined as follows:

$$a = -(2\pi/T_0)^2 \theta_0 r \sin \frac{2\pi t}{T_0}\,. \qquad (3.1.9\text{-}2)$$

Amplitude values of the forces per the leg unit length are determined by z coordinate.
transverse forces —

$F_{TS} = m(z)g\sin\theta_0$ — static force;
$F_{LD} = m(z)\varepsilon_0 d$ — inertia force; (3.1.9-3)
$F_W = \frac{1}{2}\rho_W C_D[W(z)\cos\theta_0]^2$ — wind force

longitudinal forces —
$F_{LS} = m(z)g\cos\theta_0$ — static force;
$F_{LD} = m(z)\varepsilon_0 d$ — inertial force (3.1.9-4)

where $m(z)$ = unit mass;
$W(z)$ = wind velocity at z level;
g = acceleration of gravity force
$\varepsilon_0 = 2\pi/T_0$.

Natural period of rolling or pitching may be determined by the formula:

$$T_0 = 2p\sqrt{(r_0^2 - a_0^2)/gGM} \quad (3.1.9\text{-}5)$$

where r_0 = radius of inertia for rolling or pitching in relation to the axis located in the water line level, in m;
a_0 = vertical distance between the water surface and true rotation axis during rolling or pitching, in m,
GM = transverse or longitudinal metacentric height, in m.

The distance a_0 for preliminary analysis may be accepted between the water surface and center of gravity.

The radius of inertia r_0 may be determined as follows:

$$r_0 = \sqrt{I_m/M_m} \quad (3.1.9\text{-}6)$$

where $I_m = I_L + I_H + I_A$ — moment of inertia of the masses with regard to relation of rolling and pitching;
$M_m = nM_L + M_H$ — mass;
n = the number of legs;
I_L = moment of inertia of the leg masses;
I_H = moment of inertia of the hull mass;
I_A = added mass of the moment of inertia;
M_L = mass of the leg;
M_H = mass of the hull.

3.1.10 Leg pounding against seabed during preload of self-elevating unit.

During installation and pulling out the leg may be subjected to pounding against seabed, caused by the unit rolling.

Pounding force caused by rolling may be determined by the simplified method based on the following:

only one leg touches seabed;

the lower end of the leg comes to a stop immediately upon touching seabed;

seabed is extremely hard.

The unit rotation energy is absorbed by the leg structure that gives the pounding force P

$$P = \frac{2\pi\theta_0}{T_0}\sqrt{KI_m} \quad (3.1.10\text{-}1)$$

where I_m = moment of inertia of the unit mass in relation to rolling or pitching;
θ_0 = amplitude of rolling;
K = total transverse stiffness of the leg.

The result will depend on wave condition intensity and waterarea depth.

The maximum permissible pounding force may be determined on the basis of strength criterion. The maximum permissible amplitude of rolling and pitching during installation and pulling out is to be as follows:

$$[\theta_0] = TP_{max}/2\pi\sqrt{KI_m}\,. \quad (3.1.10\text{-}2)$$

3.1.11 Ice strength of self-elevating units' legs.

Generally, self-elevating units are not designed for ice operation. Nevertheless, prolongation of the period of self-elevating unit operation in ice inclusive leads to necessity of safety assuring in view of prolongation of drilling time.

For solving this task it is necessary to identify the intensity of interaction of the ice field with the mass m_i, moving with the speed v_i, and self-elevating unit structures. At this, one is to consider flexibility of the self-elevating unit's leg.

As the load from moving ice fields the least of the two following is to be taken: that of the field stop or breaking the ice.

3.2 SEMI-SUBMERSIBLE UNITS

3.2.1 General.

3.2.1.1 In accordance with 2.4, the structural integrity of a semi-submersible unit is to be tested for three different modes:

survival;

operation;

transit;

according to 2.4.

General recommendations concerning loads to be assigned during each of the above modes are to be found under 2.3.

3.2.1.2 A unit in the survival mode is to have a clearance h_κ, in m, determined as:

$$h_c < 0{,}6h_{50} + 0{,}5 \quad (3.2.1.2)$$

where h_{50} = maximum wave height, in m, for the particular service area (once in 50 years).

3.2.1.3 For assessing by the fatigue strength criterion, the whole of the long-term distribution spectrum $P(h_3, T_c)$ for the area in question or an area with the severest wave conditions is to be used, as well as the service life of the unit as a whole.

3.2.1.4 The wave load represents a system of mutually balanced hydrodynamic loads on the surface of the unit and of three-dimensional inertia loads due to the proper weight of the unit, which are generated by the unit's rolling in waves.

For determining the loads, the linear theory of rolling in waves may be applied.

3.2.1.5 When making hull strength calculations for a semi-submersible unit, one is to be guided by the provisions of 2.5 and by the instructions below.

3.2.1.6 Any damage to a primary hull member or bracing is not to involve a collapse of the hull of the unit. The Register may require for calculations to be submitted to confirm that the hull strength will be ensured with a primary hull member or bracing damaged under external loads corresponding to the maximum loads during a year for the service area in question.

3.2.1.7 Watertight submersible or semi-submersible hull structural elements (compartments) are to be equipped with the watertightness break detection facilities.

3.2.2 Global loads.

3.2.2.1 The global loads upon the hull of a unit in waves may be determined by means of a calculation procedure approved by the Register and taking the rolling of the unit and the random character of waves into consideration, or by an experimental procedure based on special model tests which ensure the dependability of results and their adequacy as compared to those of full-scale testing.

3.2.2.2 Global wave loads may be represented as distributed loads or design values of integral characteristics of load components with indication of calculation methods for the relevant distributed loads and design load combinations to determine the global stresses for each design mode of operation.

The distributed loads which are generally determined in respect of an idealization of the hull of the self-elevating unit used for rolling calculations and to determine the deflected mode of hull structures are to be transformed bearing in mind the adopted idealization and the realization of the finite element method applied.

3.2.2.3 As the integral characteristics, the four components of the wave load are generally considered: Q_1 the symmetrical component; Q_2 the oblique-symmetrical component; Q_3 the torque acting in the centre plane of the unit; and Q_4 the shearing force applied to one fourth of the unit length in the long-term distribution of wave modes or their dispersion in a stationary mode.[1]

3.2.2.3.1 The integral characteristic of the symmetrical horizontal component of load:

$$Q_1^l = \frac{1}{2}\int_L (q_y^l - q_y^r)dx = -Q_1^r. \qquad (3.2.2.3.1\text{-}1)$$

The relevant horizontal distributed load, in t/m,

$$q_1^l = Q_1^l/L \text{ и } q_1^r = Q_1^r/L = -Q_1^l/L \qquad (3.2.2.3.1\text{-}2)$$

is applied in the waterline plane when in the transit mode and in the pontoon deck plane when in the operating and survival modes.

3.2.2.3.2 The integral characteristic of the asymmetrical component:

$$Q_2^l = \frac{1}{2}\int_L (q_z^l - q_z^r)dx = -Q_2^r. \qquad (3.2.2.3.2\text{-}1)$$

The relevant distributed load is represented in each pontoon section by the distributed vertical force q, in t/m, and moment M, in t:

$$q_2^l = Q_2^l/L \text{ и } M_2^l = (Q_2^l/L)(b_0 + B_1) \qquad (3.2.2.3.2\text{-}2)$$

and

$$q_2^r = -Q_2^l/L \text{ и } M_2^r = M_2^l, \qquad (3.2.2.3.2\text{-}3)$$

with q_2 applied in the centre plane of the pontoons and with M_2 acting with regard to the crossing line of the pontoon centre plane and the waterline when in the transit mode, and of the centre plane and the pontoon deck plane when in the operating and survival modes.

3.2.2.3.3 The integral characteristic of the torsional component (in the centre plane of the unit):

$$Q_3^l = \frac{1}{2}\int_L x(q_z^l - q_z^r)dx = -Q_3^r. \qquad (3.2.2.3.3\text{-}1)$$

The relevant vertical distributed forces, in t/m:

$$q_3^l = \frac{12Q_3^l}{L^3}\,x \text{ и } q_3^r = -\frac{12Q_3^r}{L^3}\,x \qquad (3.2.2.3.3\text{-}2)$$

are applied in the centre plane of the pontoons.

3.2.2.3.4 The integral characteristic of the symmetrical vertical component:

$$Q_4^l = \frac{1}{2}\int_{L/4} (q_z^l - q_z^r)dx = Q_4^r. \qquad (3.2.2.3.4\text{-}1)$$

The relevant vertical distributed forces, in t/m:

$$q_4^l = q_4^r = (2\pi Q_4^l/L)\cos(2\pi x/L) \qquad (3.2.2.3.4\text{-}2)$$

are applied in the centre plane of the pontoons.

The relationships under 3.2.2.3.1 to 3.2.2.3.4 include the following parameters:

q_z^l, q_y^l, M^l and q_z^r, q_y^r, M^r = distributed vertical and horizontal components of force and the moment for the left and right pontoon, respectively, each of which represents a sum of disturbing, restoring, hydrodynamic and inertia masses, as well as proper weights, of forces and moments whose major vector and moment are zero;

L, B_1 = length and breadth of pontoon hull, respectively;

b_0 = distance between inner sides of pontoons.

3.2.2.4 Stresses determined on the basis of design values of the integral characteristics of load compo-

[1] These components are present in a semi-submersible unit of classical type whose structure includes two pontoons, 4 to 8 stabilizing columns, upper hull and, generally, bracings.

nents have the same probability of exceedance as those characteristics. To determine global design stresses, load component compositions are to be used, as given in Table 3.2.2.4.

For stresses determined on the basis of distributed loads, long-term distribution or stress dispersions on stationary seas are to be determined to be able to determine the magnitude of stresses with the same probability of exceedance as prescribed under 2.3 for wave conditions during the design modes of a semi-submersible unit operation.

3.2.2.6 Hydrodynamic loads upon bracings are to be determined in accordance with 2.3.9.

The design values of the added mass coefficient C_m are to be determined by the procedure approved by the Register. The design values of the resistance coefficient C_{sr} are not to be less than indicated in Fig. 3.1.4.1.

3.2.2.7 The velocity component of the load may be ignored for calculation purposes, provided:

$$h_{3\%} \leqslant \pi D C_{in} / C_{sr} \qquad (3.2.2.7)$$

where $h_{3\%}$ = wave height with 3 per cent probability of exceedance;

$C_{in} = 1 + C_m$.

3.2.3 Local loads.

3.2.3.1 Local loads account for the intensity of the transverse load upon the shell plating, stiffeners, deck of pontoons, stabilizing columns and upper hull.

3.2.3.2 The total local load includes a permanent and a variable component.

3.2.3.3 The permanent load is determined as the difference between the external (with regard to the compartment) and the internal pressure.

As the design value, the most unfavourable value of this difference is to be considered. Where the internal pressure is generated by a consumable cargo or ballast, it is to be adopted zero when determining the design local load.

3.2.3.4 Variable local pressures, in kPa, are to be determined by the following formulas:

for submerged section of structure —

$$p = g\rho \frac{h_{3\%}}{2} c e^{-kz}; \qquad (3.2.3.4\text{-}1)$$

for above-water section of structure —

$$p = g\rho \left(\frac{h_{3\%}}{2} c - z_1\right), \text{ but not less than 5 kPa} \qquad (3.2.3.4\text{-}2)$$

where $h_{3\%}$ = wave height of three per cent probability of exceedance, in m, for the sea condition whose probability $P(h_{3\%}, T_c) \approx 10^{-2}$, for the long-term distribution in the service area in question;

c = factor accounting for wave diffraction and pressure field non-uniformity on the contour of a submerged element, $c = 1,5$;

$k = 4\pi^2 / gT_c^2$;

T_c = average period, in s, in the sea condition of 10^{-2} probability;

z = immersion, in m, of a point of submerged section of structure under free surface of water;

z_1 = height, in m, of a point of the above-water section of structure above free surface of water;

g = gravity acceleration, in m/s²;

ρ = sea water density, in t/m³.

3.2.3.5 Impact loads upon bracings.

3.2.3.5.1 The design rate v_0 of relative displacement of the forward transverse horizontal bracing, provided it is immersed (the amplitude R_0 of the relative displacement $R > 2b_1$, where b_1 is the distance from the lower bracing edge to the water surface), may be described by the expression

$$v_0^2 = 2D_v(4ln10 - 2b_1^2/D_r) \qquad (3.2.3.5.1)$$

where D_v and D_R = rate and displacement dispersions of the relative movement of the bracing.

The dispersions D_v and D_R are to be determined with due regard for the wave motion of water, as well as the heaving and pitching of the unit, on the encounter angle with regard to the waves in the transit and survival modes (paras 2.3.2.2 and 2.3.4.4) and by procedures agreed by the Register.

Table 3.2.2.4

Operation mode of semi-submersible unit	Design wave height	Position of unit with regard to the waves	Design load composition
Transit conditions	$h_{3\%} = h_{per}$ [1] $T_c = \overline{T}_c$ [2]	Straight course ($\varphi = 0$ or to 180°) Oblique course Course beam to the sea	Q_4; $0,3Q_1$; $0,3Q_2$ and $0,3Q_3$ Q_3; $0,3Q_1$; $0,3Q_2$ and $0,3Q_4$ Q_1; Q_2; $0,3Q_3$ and $0,3Q_4$
Operating conditions and survival	h_{min}[3] $\leqslant h_{3\%} \leqslant h_{per}$ Where the range of $h_{3\%}$ is in accordance with the values prescribed for the mode of operation, T_c is to comply with the long-term distribution	Straight course ($\varphi = 0$ or to 180°) Oblique course Course beam to the sea	Q_4; $0,3Q_1$; $0,3Q_2$ and $0,3Q_3$ Q_3; $0,3Q_1$; $0,3Q_2$ and $0,3Q_4$ Q_1; Q_2; $0,3Q_3$ and $0,3Q_4$

[1] h_{per} = permissible wave height with 3 per cent probability for the particular mode of operation.
[2] $\overline{T}_c$ = mean value of average period of stationary sea conditions with $h_{3\%} = h_{per}$.
[3] h_{min} = minimal wave height of 3 per cent probability for survival (for operating conditions $h_{min} = 0$).

3.2.3.5.2 The design distributed impact load, in t/m, will be determined as:

$$q_{ym} = 1{,}47 v_0^2 \rho D \qquad (3.2.3.5.2)$$

where D = bracing diameter, in m.

3.2.3.5.3 The maximum design amplitude of displacement z_0 of the middle section of the bracing in the process of elastic vibrations and the relevant stresses σ_y will be determined by the formulas:

$$z_0 = \frac{F_r}{K_r} \frac{2{,}72 a_1}{(1 + a_1^2)^2} \{[2a_1 + (1 + a_1^2)\omega_1 t](1/2{,}72) -$$

$$- 2a_1 \cos\omega_1 t - (1 - a_1^2)\sin\omega_1 t\}; \qquad (3.2.3.5.3\text{-}1)$$

$$\sigma_y = (ED/2) z_0 f_1''(y) \qquad (3.2.3.5.3\text{-}2)$$

where $a_1 = v_0/0{,}145 D\omega_1$;

$\omega_1 = K_r/M_r$ = basic frequency of elastic vibrations of the bracing;

$F_r = \int_0^l q_{ym} f_1 dy + F_{l/2} f_1$ = reduced force;

$K_r = \int_0^l EJ(f_1'')^2 dy + K_{l/2} f_1$ = reduced rigidity;

$M_r = \int_0^l m f_1^2 dy + m_{l/2} f_1^2$ = reduced mass;

f_1 = basic vibration mode to be determined by the formula

$$f_1 = 0{,}5(\cos \frac{2\pi y}{l} - 1) + (1 - \sin \frac{\pi y}{l}), \qquad (3.2.3.5.3\text{-}3)$$

or the shape of girder bending is to be determined with due regard for the rigidity of embedding , for stiffener fitted in the span and having a rigidity $K_{l/2}$ and for other peculiarities of the girder revealed under the effect of a uniformly distributed load involving a single deflection at the point of its reduction.

3.2.3.5.4 Stresses σ_y are to be considered when determining the total stresses in the bracing due to local and total loads in the transit and survival condition.

3.2.4 Determination of deflected mode.

3.2.4.1 A platform construction is considered a linear system. Therefore, stresses in the structure may be generated as a result of superposition of the effects of particular load components.

3.2.4.2 For analysing the deflected mode of the construction of a semi-submersible unit as a whole, the method of finite elements is recommended. To this end, the following three-dimensional models may be applied: beam model, plate model and plate-beam model.

The application of the beam model is advisable at initial design stages. It is also convenient where there are many bracings fitted at random.

The application of the plate and the plate-beam models is advisable at the final stages of design. The latter model implies an idealization in the form of finite beam elements or bracings only, or bracings, stabilizing columns and pontoons.

3.2.4.3 When analiysng the deflected mode of the construction of a semi-submersible unit as a whole on the basis of the beam model, the following is to be done:

.1 finite beam elements with six degrees of freedom in the connection are to be used which would account for bending and shifting deformations in two planes, tension-compression and twisting deformations;

.2 geometrical characteristics of cross sections of the elements by which pontoons, stabilizing columns and bracings are approximated are to be determined proceeding from the condition that the longitudinal members including shell plating, longitudinal stiffeners and other longitudinal elements will contribute with their full area to the construction behaviour.

.3 geometrical characteristics of cross sections of the elements by which the structures of the upper hull are approximated are to be determined in accordance with the provisions of 3.2.4.4;

.4 where elements of large cross sections are connected (stabilizing column to a pontoon or bracing, for instance, (see Fig.3.2.4.3.4), etc.), either "absolutely rigid" finite elements are to be introduced or finite beam elements with rigid ends are to be used.

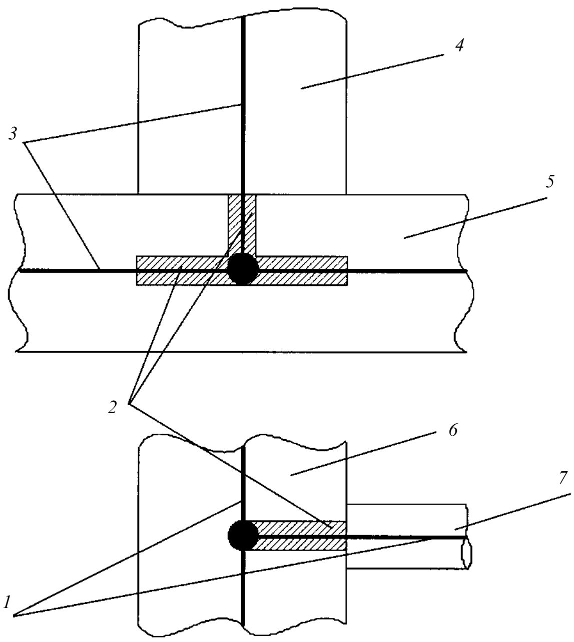


Fig. 3.2.4.3.4
"Absolutely rigid" finite elements:
1, 3 = bar finite elements; *2* = "absolutely rigid" finite elements; *4, 6* = stabilizing column; *5* = pontoon; 7 = *b*racing.

3.2.4.4 Provisions for determining the geometrical characteristics of cross sections of elements by which the upper hull structure is approximated stipulate the following:

3.2.4.4.1 The upper hull structure (Fig. 3.2.4.4.1-1) may be represented as a system of beam elements (Fig. 3.2.4.4.1-2) possessing the properties of a real structure. The geometrical characteristics of cross sections of the beam elements are as follows:

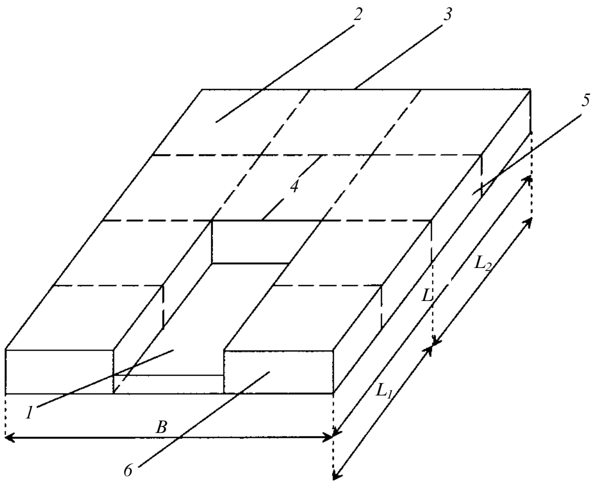


Fig. 3.2.4.4.1-1 Plan of upper hull structure (example);
B = upper hull breadth; L = upper hull length;
L_1, L_2 = lengthwise span between stabilizing column axes;
1, 2 = deck; 3, 6 = transom; 4 = bulkheads; 5 = side

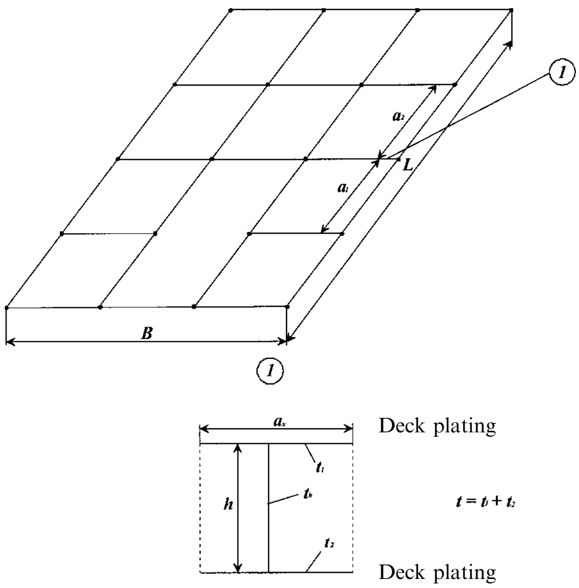


Fig. 3.2.4.4.1-2
Beam model of upper hull (example):
1 = bar element considered and its cross section;
a_x = effective flange breadth;
a_1 and a_2 = distance from the element in question to the nearest element arranged in the same direction;
B = upper hull breadth; L = upper hull length

J_x = inertia moment of the cross-sectional area of an element with regard to the horizontal axis;

J_z = inertia moment of the cross-sectional area of an element with regard to the vertical axis;

J_{tor} = torsional inertia moment of the cross-sectional area of an element;

F_x = cross-sectional area of an element taking up a shift in the horizontal direction;

F_z = cross-sectional area of an element taking up a shift in the vertical direction;

$F_{t\text{-}com}$ = cross-sectional area of an element in tension and compression.

3.2.4.4.2 The inertia moment J_x is determined by the web height and the effective flange breadth $a_x$which depends on the span length of the element b and the type of structural deformation. To be considered are all the longitudinal members adjoining the element.

For transverse elements, the span length b is to be adopted equal to the upper hull breadth where intermediate supports in the form of bracings are missing, or to half the upper hull breadth where intermediate supports in the form of bracings are fitted. For longitudinal elements, the span length b is to be adopted equal to the lengthwise distance between the stabilizing columns axes.

The following types of structural deformation are distinguished: symmetrical bending and oblique-symmetrical bending. In the case of symmetrical bending, the width of the effective flange of elements will be adopted equal to the lesser of the values to be determined by the formulas:

$$a_x = \frac{1}{3}b; \qquad (3.2.4.4.2\text{-}1)$$

$$a_x = 0{,}5(a_1 + a_2). \qquad (3.2.4.4.2\text{-}2)$$

In the case of oblique-symmetrical bending, the width of the effective flange of elements is to be adopted equal to the lesser of the values to be determined by the formulas:

$$a_x = \frac{1}{6}b; \qquad (3.2.4.4.2\text{-}3)$$

$$a_x = 0{,}5(a_1 + a_2) \qquad (3.2.4.4.2\text{-}4)$$

where a_1, a_2 = distances from the element considered to the nearest elements arranged in the same direction and fitted on both sides of the former elements, m.

3.2.4.4.3 The inertia moment J_z, m^4, is to be determined by the formula

$$J_z = (ta_z^3/12)(1/n_z) \qquad (3.2.4.4.3\text{-}1)$$

where t = total design thickness, in m, of deck plating;
a_z = effective flange thickness, in m, in the case of bending with regard to the vertical axis;
n_z = number of transverse elements on the upper hull length for the purpose of J_z determination for transverse elements, or the number of longitudinal elements on the upper hull breadth for the purpose of J_z determination for longitudinal elements.

The effective flange width a_z is to be determined by the formula

$$a_z = B\sqrt[3]{(L/2B)\frac{1}{1+v}} \qquad (3.2.4.4.3\text{-}2)$$

where B = upper hull breadth, in m, for transverse elements, or upper hull length, in m, for longitudinal elements;

L = upper hull length, in m, for transverse elements, or upper hull breadth, in m, for longitudinal elements;
ν = Poisson's ratio.

3.2.4.4.4 For the purpose of determining the inertia moment J_{tor}, the upper hull is to be considered, in each of its longitudinal or transverse sections, as a closed system(s) bounded on its contour by the plating of deck and sides (transoms, bulkheads).

The inertia moment J_{tor}, m^4, is to be determined by the formula

$$J_{tor} = (4S^2/\int dl/t_c)(1/n_{tor}) \qquad (3.2.4.4.4)$$

where S = area, in m, of a closed contour formed by the plating of decks and sides (transoms, bulkheads) of the closed system considered;
dl and t_c = element of the contour perimeter length and its web thickness, in m, at the perimeter point under consideration;
n_{tor} = number of transverse elements forming the closed system, for the purpose of determining J_{tor} for transverse elements, or the number of longitudinal elements forming the closed system, for the purpose of determining J_{tor} for longitudinal elements.

The bending moment discontinuities at the points of longitudinal and transverse member intersection of the upper hull, which are due to the method of J_{tor} specification, are to be smoothed by averaging the bending moment values.

3.2.4.4.5 Unless it is proved that the shift may be ignored ($F_x \to \infty$), the cross-sectional area F_x is to be determined by the formula

$$F_x = 0{,}5(a_1 + a_2)t \qquad (3.2.4.4.5)$$

where for a_1, a_2 see 3.2.4.4.2;
for t, see 3.2.4.4.3.

3.2.4.4.6 Unless it is proved that the shift can be ignored ($F_z \to \infty$), the cross-sectional area F_z, m, will be determined by the formula

$$F_z = ht_h \qquad (3.2.4.4.6)$$

where h = height, in m, of element cross section;
t_h = design web thickness of element, in m.

3.2.4.4.7 The cross-sectional area $F_{t\text{-}com}$ depends on the web height and the effective flange width $a_{t\text{-}com}$. All the longitudinal members adjoining the element are to be considered.

The effective flange width is to be determined by the formula

$$a_{t\text{-}com} = 0{,}5(a_1 + a_2) \qquad (3.2.4.4.7)$$

where for a_1, a_2, see 3.2.4.4.2.

3.2.4.5 In accordance with para 2.4.3.9 of this part, the loss of stability of the plates of primary and secondary structural elements may only be permitted for the deck plating of the upper hull. In this case, the reduction of elastic members (plates) under the effect of design compressive stresses is to be considered for calculation purposes.

3.3 FIXED OFFSHORE PLATFORMS

3.3.1 General

3.3.1.1 The strength of a FOP structure is to be checked in accordance with the strength criteria specified in 2.4 for design modes specified in 2.1.1.

The criteria of 3.3.3 of this Section are additionally to be met for ice strake structures under extreme loading. In this case, the criterion 2.4.2.3.2 for the plates of outer shell of an ice strake is to be met only for local hydrostatic and wave loadings (and also attendant thereto) and may be determinative merely in the event when local ice pressures are comparable in value with the other local loadings.

Safety factors and strength criteria for the modes of installation in and removal from a drilling position are to be assumed as for a transportation mode. Based on these requirements, the permissible environmental conditions for installation in and removal from a drilling position mode are to be refined.

The mode of removal from a drilling position in terms of strength assurance is necessarily to be considered for FOP, which may repeatedly change their location area during life cycle.

For FOP whose operation is expected to be in one location only during the entire life cycle, the mode of removal from a drilling position is subject to special consideration by the Register.

3.3.1.2 The FOP upper hull clearance h_w, in m, is to be not less than the largest of values determined for extreme effects of waves and ice:

for waves —

$$h_w = \Delta_{100} + 1{,}2(D/\lambda_{100})^{1/4}h_{100} + 1{,}5 \qquad (3.3.1.2\text{-}1)$$

where $\Delta 100$ = peak amplitude of a sea level change which is probable once in 100 years, m;
h_{100} = wave height which is probable once in 100 years, m;
λ_{100} = wave length which is probable once in 100 years, m;
D = diameter of a cylindrical leg or the cross dimension of a conic leg at the waterline level, m;

for ice —

$$h_{‰} = 4h_{l100} + \Delta_{100} + 0{,}5 \qquad (3.3.1.2\text{-}2)$$

where h_{l100} = thickness of rafted ice which is probable once in 100 years, m.

Where structural details like lugs, inserts, etc. are available, the value of clearance for ice conditions is determined experimentally.

3.3.1.3 In shallow waters a whipping (splashing over) phenomenon may be observed. At present, its severity is effectively determined by an experimental approach only and its determination is necessary while evaluating the clearance value.

3.3.1.4 Calculating FOP hull strength, the provisions of 2.5 are to be followed as well as the provisions of 3.3.4.

3.3.2 Loadings.

3.3.2.1 Wave loadings.

3.3.2.1.1 Wave loading on a platform and its elements are determined on the basis of the Morison equation (see 2.3.9.1 and 2.3.9.2).

3.3.2.1.2 Only one inertia component for a FOP at $D > h_{100}/\pi$ is to be considered. Then, in order to determine velocities and accelerations of water particles, the linear theory of waves of small amplitude may be used.

FOP may be represented by combination of different architectural forms. As the basic elements the cylindrical and conic legs are generally used. With reference to these elements, the wave load parameters are given in 3.3.2.1.3 to 3.3.2.1.7.

3.3.3.1.3 For structures of an exactly cylindrical configuration, the standard deviation of the horizontal component of a wave loading, MN, may be determined by the formula

$$\sigma_Q^{hor} = 3 \cdot 10^{-3} \gamma (h_3)_{\max} D^2 K_v th\overline{K}H; \qquad (3.3.2.1.3\text{-}1)$$

and the standard deviation of the horizontal component of a wave loading on a conic leg, by the formula

$$\sigma_Q^{hor} = 3 \cdot 10^{-3} \gamma (h_3)_{\max} D^2 K_v th\overline{K}H \times$$

$$\times \{1 - \frac{4}{\overline{K}Dtg\alpha}(\overline{K}H - 1/\overline{K}H + 1/sh\overline{K}H) + \frac{4}{(\overline{K}D)^2 (tg\alpha)^2} \times$$

$$\times [2 + (\overline{K}H)^2 - 2\overline{K}H/th\overline{K}H]\} \qquad (3.3.2.1.3\text{-}2)$$

where γ = water density, t/m^3;
$(h_3)_{max}$ = wave height with 3 per cent probability, m (see 2.2.2.5);
D = diameter of a cylindrical leg or the cross dimension of a conic leg at the bottom level, m;
$\overline{K} = 2\pi/\overline{\lambda}$ = wave number;
$\overline{\lambda}$ = average wave length, m;
K_v = diffraction correction (see 2.3.9.2; in this case the diameter d refers to that at the waterline level);
α = angle of a cone inclination to horizon (the leg is vertical when $\alpha = 90°$);
H = depth in a water area, m.

3.3.2.1.4 The coordinate of a horizontal wave loading component applied to a cylindrical leg and measured from the seabed level is determined by the formula

$$Z_0/H = \frac{1}{\overline{K}H} \cdot (1 - ch\overline{K}H + \overline{K}H \cdot sh\overline{K}H)/sh\overline{K}H. \qquad (3.3.2.1.4)$$

3.3.2.1.5 The vertical force due to waves effect depends on permeability of a base associated with the soil type. In the absence of permeability, the vertical force may be neglected. For a rocky or large-shingle bed, the vertical force is to be taken into account and when an additional capsizing moment (see 3.3.2.1.7) is determined as well.

3.3.2.1.6 The design value of a horizontal component of a wave loading on a platform in the most severe mode is allowed to determine using the formula

$$Q = \sigma_Q \sqrt{2lnpN} \qquad (3.3.2.1.6)$$

where σ_Q = standard deviation according to 3.3.2.1.3;
p = recurrence of an extreme mode determined by statistical data for a given operational area defined by the $(h_3)_{\max}$ value (see 2.2.3.5);
N = sampling extent appropriate to the entire life cycle (with a view to an ice period).

3.3.2.1.7 The design value of an overall capsizing moment due to waves effect on a vertical cylindrical platform standing on permeable seabed is to be determined by the formula

$$M_c = \sqrt{(QZ_Q)^2 + M_V^2} \qquad (3.3.2.1.7\text{-}1)$$

where Q = see 3.3.2.1.6;
Z_Q = coordinate of loading application to a cylindrical leg, m;
M_V = additional capsizing moment due to vertical wave pressures determined by formula

$$M_V = \sigma_{M_V} \sqrt{2ln(pN)}\ ; \qquad (3.3.2.1.7\text{-}2)$$

σ_{M_V} = standard deviation of an additional capsizing moment determined as:

$$\sigma_{M_V} = \frac{\gamma h_3 D^3}{ch(2\pi H/\overline{\lambda})} \psi_V; \qquad (3.3.2.1.7\text{-}3)$$

ψ_V = coefficient of the additional capsizing moment due to waves effect on the foundation of an obstacle with due regard for permeability of a base determined according to Fig. 3.3.2.1.7.

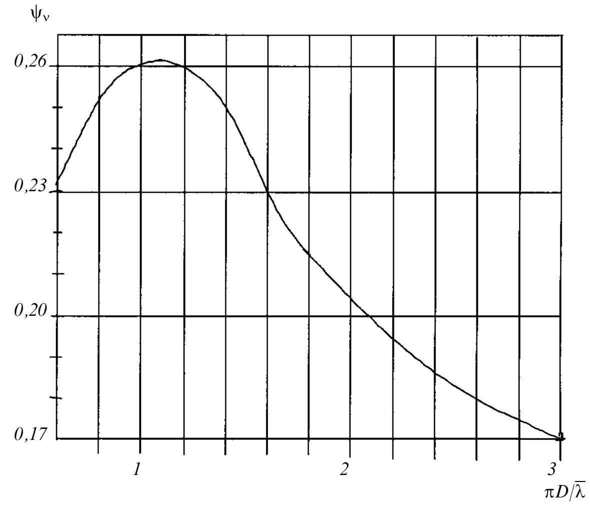


Fig. 3.3.2.1.7 Value of an additional capsizing moment parameter ψ_v

3.3.2.1.8 The design wave loading on a multileg structure is determined as the sum of wave loadings on the legs and the loading on an underwater pontoon:

.1 the wave loading on legs is determined by the formula

$$Q = n\sigma_Q\gamma_n\sqrt{2ln(pN)} \qquad (3.3.2.1.8.1)$$

where n = number of legs;
σ_Q = standard deviation according to 3.3.2.1.3;
γ_n = coefficient of influence of the distance L between n legs on a wave loading which corresponds to the heading angle φ_d determined as:

$$\varphi_d = \frac{\pi}{n}(2;-1),\ i = 1,\ 2,\ ...\ n,$$

$$\gamma_n = \frac{1}{\sqrt{2}}\sqrt{1 + \cos(\overline{\omega}^2 L_n/g)}\ ;$$

$$L_n = \begin{cases} L_4 = \sqrt{2}L \\ L_3 = \frac{\sqrt{3}}{3}L; \end{cases}$$

p = recurrence of an extreme mode;
N = sampling extent, $N = 10^8$

$$\varphi_d = \frac{\pi}{n}(2i-1),\ i = 1,2,...n\ ;$$

.2 the loading on an underwater pontoon is determined by the formula

$$Q = (\gamma\pi h/2)D^2(shKd/chKH)\beta \qquad (3.3.2.1.8.2)$$

where γ = water density, t/m^3;
h = design wave height (with 1 per cent probability, m);
D = reduced diameter of pontoon, m;
$D = \sqrt{4S/\pi}$
where S = pontoon area in plan, m^2;
d = pontoon height, m;
H = water area depth, m;
λ = wave length (with 1 per cent probability) taken into consideration, m;
β = coefficient depending on the ratio $\pi D/\overline{\lambda}$ (see Fig. 3.3.2.1.8.2)

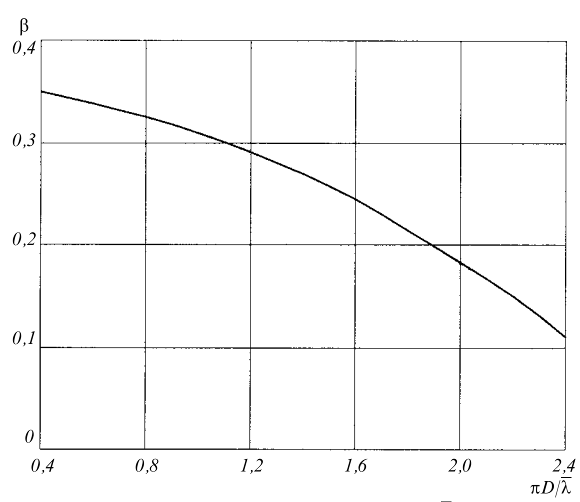


Fig. 3.3.2.1.8.2 Coefficient β — $\pi D/\overline{\lambda}$

3.3.2.1.9 Where a FOP differs architecturally from the forms considered, the adequate calculation methods are to be used; the experimental analysis is be used, when deemed necessary.

3.3.2.1.10 The peak value of a local wave pressure applied to a hull structure at large and its separate components in an open water area for the region of alternating waterlines (by 8 m up and down from a design waterline) is to be assumed in accordance with Table 3.3.2.1.10; for the structures located above the region of alternating waterlines and below the clearance height in terms of waves, the design pressure is 0,05MPa, and for the above located structures, extending the outboard side, at least 0,02MPa.

Table 3.3.2.1.10

Surface orientation	Pressure, MPa	
	FOP in service	Transportation of a FOP at large or of its separate blocks[1]
Vertical	0,15	0,10
Deviation from a vertical for more than 30°	0,10	0,05

[1]Data are given without regard for slamming; to be increased if slamming is allowed for.

3.3.2.2 Wind and current loadings.

3.3.2.2.1 Wind loadings are determined by the Formula (2.3.8).

3.3.2.2.2 Current loadings are obtained with due regard for summation of current velocities v_c, m/s, and orbital velocities of water particles in wave v, m/s.

In this case, wave pressures on a cylindrical element are determined as:

$$q = (\rho C_v d/2)(v + v_c)|v + v_c|. \qquad (3.3.2.2.2\text{-}1)$$

The v component of loading only due to a current on a cylindrical leg is determined by the formula

$$Q = (\rho C_v d/2)v_c^2 H_0, \qquad (3.3.2.2.2\text{-}2)$$

where ρ = mass water density, t/m^3;
C_v = speed resistance coefficient of an obstacle;
d = obstacle diameter, m;
H_0 = water area depth, m.

3.3.2.2.3 Evaluating wave loadings with use of spectral transformations, the transformation of a spectrum with due regard for a current is to be considered (see 2.2.4.2). As a basis calculation velocity-generated forces applied to a cylindrical led, it is recommended to use expression:

$$Q = (\rho C_v d/2)\left\{v_c^2 H_0 + \sqrt{8/\pi}(1 + v_c^2/\sigma_{v_0}^2)\left(\frac{g v_0 \sigma_{v_0}}{\overline{\omega}^2 + \omega^2}\right)\right\} \qquad (3.3.2.2.3)$$

where g = acceleration of gravity, m/s^2;
v_0 = amplitude of the orbital velocity of surface wave water particles, m/s;
σ_{v_0} = standard deviation of the orbital velocity of surface wave water particles, $\sigma_{v_0} = 0{,}19h_3\overline{\omega}$;
$\overline{\omega}$ = average waves frequency, s^{-1};
h_3 = wave height with 3 per cent probability, m;
ω = waves frequency, s^{-1}.

3.3.2.3 Ice loadings.

3.3.2.3.1 Ice loadings are classified as global and local. The global loadings are divided into horizontal and vertical, and comprise permanent and variable parts. The global loadings may be static and dynamic.

3.3.2.3.2 Global loadings are generated by level and rafted ice, and by pressure ridges. Determination of global loadings is the basis for extreme and fatigue assessments.

3.3.2.3.3 The global loading (in MN) on a cylindrical leg due to level or rafted ice is determined by the formula

$$F_{hor} = a_h[1 + (0{,}75K - 0{,}1)\vartheta_{\sigma_c}](\ln n)^{1/K} D\overline{\sigma}_c \qquad (3.3.2.3.3\text{-}1)$$

where a_h = parameter of ice thickness distribution scale, m;
D = obstacle diameter, m;
$\overline{\sigma}_c$ and ϑ_{σ_c} = mean value and the coefficient of variation of ice compression strength as determined in 2.2.5 with due regard for the recommendations of this Section, MPa;
n = sampling extent, $n = 1/p$ (p = level of design probability of exceedance);
K = parameter of the form of an ice loading distribution, which depends on the ratio a_h/D (see Fig. 3.3.2.3.3-1).

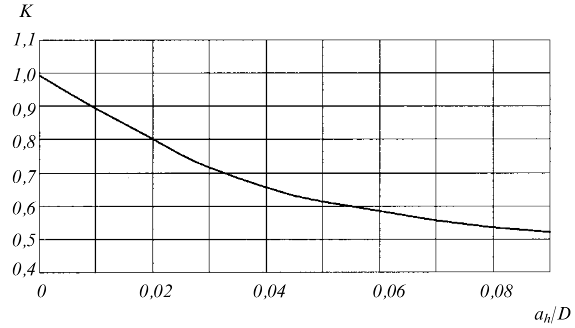


Fig. 3.3.2.3.3-1 Form parameter K — a_h/D relation

The ice strength $\overline{\sigma}_c$ is recommended to be determined in relation to the deformation rate $\dot{\varepsilon}$. The deformation rate is determined from the condition

$$\dot{\varepsilon} = v/4D \text{ at } D/h < 30 \text{ and } \dot{\varepsilon} = v/2D \text{ at } D/h > 40 \qquad (3.3.2.3.3\text{-}2)$$

where $\dot{\varepsilon}$ = to be determined by a linear interpolation at $30 \leqslant D/h \leqslant 40$;
D = obstacle diameter, m;
h = thickness of level or rafted ice, m;
v = drift speed, m/s.

If data on the parameter of ice thickness distribution scale (parameter of long-term ice thickness distribution) are lacking, the last is recommended to be evaluated by the formula

$$a_h = 0{,}22h_{100} \qquad (3.3.2.3.3\text{-}3)$$

where h_{100} = ice thickness corresponding to 1 per cent probability (once in 100 years).

The relation between $\overline{\sigma}_c$ and the deformation rate $\dot{\varepsilon}$ is defined by the parameter K_V in Fig. 3.3.2.3.2-2.

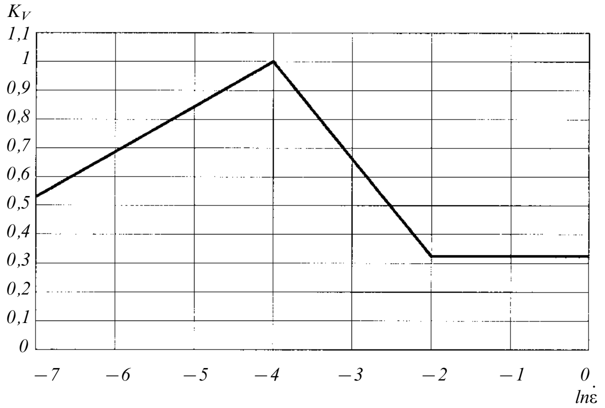


Fig. 3.3.2.3.3-2 Graphic relation of the parameter of ice drift speed influence on an ice loading

The design value of a drift speed v is selected as the most probable for the ice thickness assumed and ice strength. If data on the most probable drift speed for the ice thickness assumed and ice strength are lacking, the parameter K_V is taken to be 1.

3.3.2.3.4 The global loading on the leg of a cylindrical form due to hummocking is determined by the formula

$$F^h_{hor} = F_{hor}K_h \qquad (3.3.2.3.4)$$

where F_{hor} = see 3.3.2.3.3;
K_h = amount of hummocking factor dependent on the relation

$\alpha = h_{cons}/h_{raf}$ (see Fig. 3.3.2.3.4);

h_{cons} = consolidated layer thickness, m;
h_{raf} = rafted ice thickness, m.

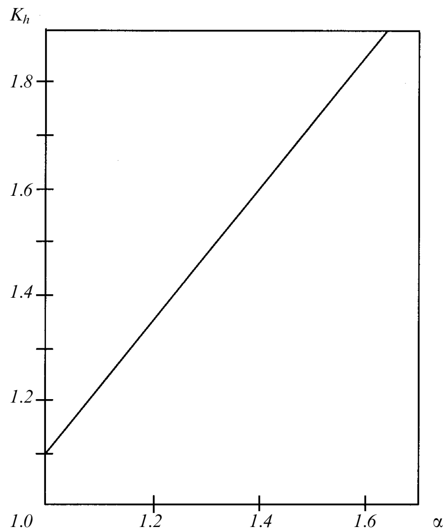


Fig. 3.3.2.3.4 Relation between an amount of hummocking factor K_h for cylindrical legs and $\alpha = h_{cons}/h_{raf}$

3.3.2.3.5 The horizontal component of a global loading, in MN, on the leg of a conic form due to level or rafted ice is determined by the formula

$$F_{hor} = F_1 + F_2 \qquad (3.3.2.3.5\text{-}1)$$

where

$$F_1 = \bar{b} a_h^2 [1 + (0{,}75K - 0{,}1)\vartheta_{\sigma_f}](\ln n)^{1/K} \bar{\sigma}_f tg(\beta + a\text{rctg}f); \qquad (3.3.2.3.5\text{-}2)$$

$$F_2 = 7{,}4 \cdot 10^{-4} a_h \beta^{1,6} \gamma_i D^2 [1 - (D_T/D)^2](\ln n) tg(\beta + \text{arctg}f); \qquad (3.3.2.3.5\text{-}3)$$

$\bar{b}$ = parameter dependent on the ice thickness distribution parameter a_h to diameter ratio (see Fig. 3.3.2.3.5-1);
K = parameter of the form of an ice loading distribution dependent on the ratio a_h/D (see Fig. 3.3.2.3.5-2);

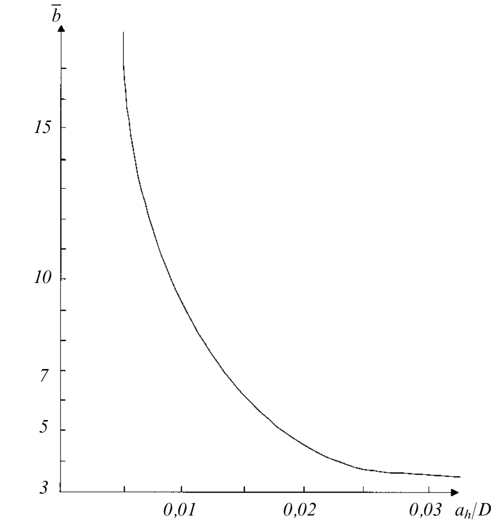


Fig. 3.3.2.3.5-1 Parameter $\bar{b}$ — ratio a_h/D relation

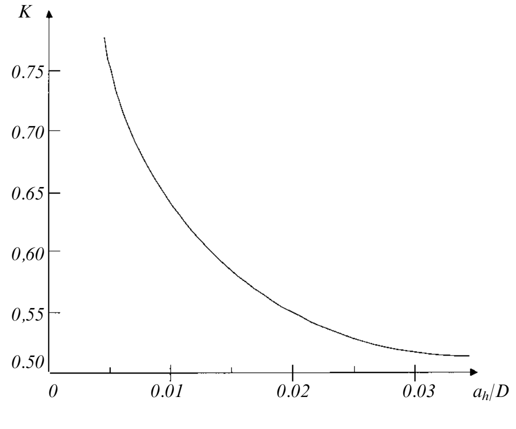


Fig. 3.3.2.3.5-2 Parameter K — ratio a_h/D relation

$\bar{\sigma}_f$ and ϑ_{σ_f} = mean value and the coefficient of variation of ice bending strength as determined in 2.2.5, MPa;
γ_i = ice density, MN/m^3;
D = diameter of a conic obstacle at the ice level, m;
D_c = upper diameter of a cone (see Fig. 3.3.2.3.5-3), m;
β = angle of inclination of the generator of a cone to horizon, degree;
f = friction coefficient;
n = sampling extent ($n = 1/p$, p = level of design probability of exceedance).

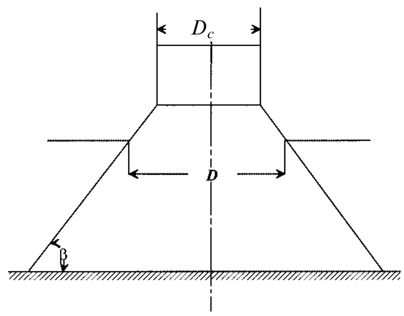


Fig. 3.3.2.3.5-3 Conic obstacle

3.3.2.3.6 The vertical component of a global ice loading on the leg of a conic form due to level or rafted ice is determined by the formula

$$F_v = (F_1 + F_2)/\text{tg}(\beta + \text{arctg}f) \qquad (3.3.2.3.6)$$

where F_1 and F_2 = see 3.3.2.3.5.

3.3.2.3.7 The horizontal component of a global ice loading, in MN, on the leg of a conic form due a pressure ridge is determined by the formula

$$F_h^{hor} = (F_1 + F_2)K_h \qquad (3.3.2.3.7)$$

where K_h = amount of hummocking factor dependent on a ratio $\alpha = h_{cons}/h_{raf}$ and an angle β (see Fig. 3.3.2.3.7).

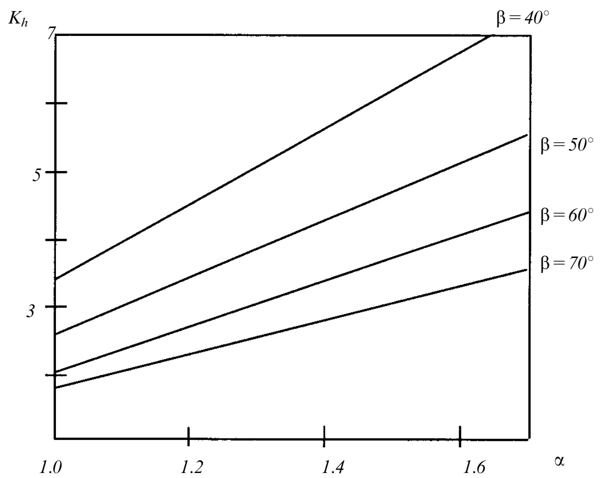


Fig. 3.3.2.3.7 Relation between the amount of hummocking factor K_h for conic legs and the ratio $\alpha = h_{cons}/h_{raf}$ and the cone angle β

3.3.2.3.8 The vertical component of a global loading, in MN, on the leg of a conic form due to a pressure ridge is determined by the formula

$$F_v = (F_1 + F_2)K_h/\text{tg}(\beta + \text{arctg}f). \qquad (3.3.2.3.8)$$

3.3.2.3.9 Irrespective of the leg form the design value of a horizontal ice loading, in MN, on a multileg structure for an ice scenario corresponding to ice clogging between legs is determined by the formula

$$F_{hor} = Bh^{0,8}K_h \quad (3.3.2.3.9)$$

where B = maximum width of an obstacle formed by legs, m;
h = design value of the rafted ice thickness, m;
K_h = amount of hummocking factor determined according to the diagram in Fig. 3.3.2.3.4.

3.3.2.3.10 The extent of an ice strake l, in m, is to be at least:

$$l = \Delta_{100} + 2\alpha h_{cons100} \quad (3.3.2.3.10)$$

where Δ_{100} = maximum swing of the sea level change relative to the average level probable once in 100 years, m;
α = safety factor; $a = 1{,}1$;
$h_{cons100}$ = thickness of the consolidated hummock layer probable once in 100 years (in the absence of hummock, the thickness of level or rafted ice), m;

The l value is symmetrically plotted up and down relative to an average water level.

3.3.2.3.11 Local ice pressures, in MPa, on structures within an ice strake of a conic obstacle are determined by the formula

$$p = \overline{\sigma}_c(1 + 2\sqrt{2/A})\,\frac{\sqrt{\beta}}{8{,}5}; \quad (3.3.2.3.11)$$

$$18^\circ < \beta < 72^\circ$$

where $\overline{\sigma}_c$ = mean value of an ice compression strength, MPa;
A = contact area, m^2;
β = angle of inclination of the generator of a cone to horizon, degree.

The pressure p at $\beta < 18^\circ$ is determined as at 18°; and at $\beta > 72^\circ$ it is determined as at 72°. The pressure p is set equal to 18 MPa when $p > 18$ MPa.

Local ice pressures on structures within an ice strake of a vertical obstacle are determined by the above formula in which factor $\sqrt{\beta}/8{,}5$ is to be omitted.

3.3.2.3.12 Local ice pressures on structures on structures in areas above and below an ice strake (see 3.3.2.3.11) are determined as the part of pressures on ice strake structures.

Local ice pressures below an ice strake with the extent of $0{,}5h_{keel}$ are determined in accordance with a relation $p_b = p/4$, but are to be not less than 2 MPa where p is in line with 3.3.2.3.11. The value of ice pressures below the areas specified (where possible) is to be determined with due regard for the details of ice situation in an operational area.

Local ice pressures on structures above an ice strake with the extent of h_{sail} are determined in accordance with a relation $p_a = p/8$, but are to be not less than 1,0 MPa where p is in line with 3.3.2.3.11.

3.3.2.3.13 The values of ice loadings may be refined on the basis of field observation or laboratory research data, and also on the basis of using special methods approved by the Register.

3.3.2.4 Seismic effects.

3.3.2.4.1 FOP operation in the areas of seismic activity is associated with loadings of an essential value applied to a structure, which may result in quite adverse consequences. In some areas, the seismic effect may be adopted as the design case of loading which defines FOP structural decisions.

FOP are to be designed and operated so as:

to prevent the threat to people's safety, of pollution of the environment with oil and gas production products, and to keep up repair ability of the structure and equipment on exposure to a design earthquake;

to avoid FOP capsizing and catastrophic pollution of the marine environment on exposure to a maximum design earthquake; in this case, other damages, which may upset the normal operation of a structure, are allowed.

Seismic stability is ensured by:

the selection of a seismically favourable building site, a structural and planning diagram, and materials;

application of special structural arrangements;

the relevant calculation of structures;

quality of construction and installation work execution;

inclusion in FOP designs of a special section on the earthquake monitoring during the structure operation.

3.3.2.4.2 Designing structures it is to be taken into account that seismic forces may have any space orientation, horizontal and vertical inclusive.

3.3.2.4.3 In calculations of FOP seismic stability the following seismic loadings are to be considered:

inertia forces generated by seismic structure shakings, and distributed in a structure space and its base;

hydrodynamic pressure on a structure generated by an inertia effect of the liquid part vibrating along with the structure, and distributed across the surface of the structure contact with water;

hydrodynamic pressure due to seismic seawaves in an earthquake.

3.3.2.4.4 Calculating seismic stability of equipment and structures located in the above-water part of a FOP, seismic effects are specified by accelerations transmitted to these structures and equipment by carrying structures of the FOP hull. In this case, the peculiarities of the dynamic interaction of objects and structures in question are to be considered.

3.3.2.4.5 FOP are calculated for the seismic effects of design and maximum design earthquake levels using methods of a dynamic theory of seismic stability.

At preliminary stages of design, a linearly spectral theory of seismic stability may be used.

3.3.2.4.6 The calculations of structures for a design earthquake according to the dynamic theory of seismic stability are conducted with use of a linear time dynamic analysis wherein the structure materials and base soils are assumed linearly elastic, and geometric and structural nonlinearity in behaviour of a structure-base system is absent.

The linear time dynamic analysis is carried out either by the method based on the solution expansion into a series to the forms of natural vibrations of the structure or by the method based on stepwise integration of a set of differential equations.

3.3.2.4.7 The calculations of structures for a maximum design earthquake according to the dynamic theory of seismic stability are conducted with the use of any techniques of time dynamic analysis (as a rule, nonlinear based on the method of stepwise integration).

The nonlinear dynamic analysis is carried out according to the special procedures and programs approved by the Register.

The calculations of structures for a maximum design earthquake according to the dynamic theory of seismic stability with use of a linear dynamic analysis are carried out similarly to the calculations of structures for a design earthquake according to the dynamic theory of seismic stability.

3.3.2.4.8 The calculations of a FOP according to a dynamic theory of seismic stability are to be conducted for design accelerograms selected (of instrumental records, analog or synthesized accelerograms) with such values of a maximum peak acceleration a_p in a base that the values of these accelerations a_p^{de} (in calculation for a design earthquake) and (in calculation for a maximum design earthquake) have the values meeting recurrences of 100 and 500 years, respectively. In this case, the following conditions are to be fulfilled:

$$a_p^{de} = k_\tau^{de} g A_{100}; \quad (3.3.2.4.8)$$

$$a_p^{mde} = k_\tau^{mde} g A_{500};$$

where k_τ^{de} = coefficient allowing for the probability of a seismic event under consideration over the design lifecycle of a FOP for the design earthquake, see Table 3.3.2.4.8-1;

Table 3.3.2.4.8-1

Design lifecycle, years	k_τ^{de}	k_τ^{mde}
10	0,5	0,70
20	0,63	0,80
50	0,70	0,90

k_τ^{mde} = coefficient allowing for the probability of a seismic event under consideration over the design lifecycle of a FOP for the maximum design earthquake, see Table 3.3.2.4.8-1;
g = acceleration of gravity, 9,81 m/s^2;
A_{100} = design amplitude of a base acceleration expressed as the g fraction; the value of A_{100} is adopted according to Table 3.3.2.4.8-2;
A500 = design amplitude of a base acceleration expressed as the g fraction; the value of A_{500} is adopted according to Table 3.3.2.4.8-2.

Table 3.3.2.4.8-2

Design seismicity of a building site J_{100}^{des} (J_{500}^{des}), magnitude	Reference seismicity of a building site $J_{100}^{ref}(J_{500}^{ref})$, magnitude			
	6	7	8	9
6,5	0,08	0,10	—	—
7,0	0,10	0,13	0,17	—
7,5	—	0,16	0,22	—
8,0	—	0,21	0,28	0,36
8,5	—	—	0,35	0,49
9,0	—	—	0,45	0,61

3.3.2.4.9 The calculations of FOP seismic stability according to a linearly spectral theory are allowed to perform by the solution of static problems of elasticity when solid inertia forces of the $\vec{P}_i(\vec{x})$, intensity corresponding to the i-th form of natural vibrations are applied to structures.

Where the system "structure — base" in a calculation is split into separate discrete volumes, then as inertia loadings are used nodal inertia forces $\vec{P}_{ik}$, acting on the structure element assigned to the node k at the i-th form of natural vibrations.

In this case, the values of nodal force components $P_{ikj,\ j} = 1, 2, 3$ are determined by the formulae:

$$P_{ikj}^{de} = 0{,}5 k_H k_\psi m_k a_p^{de} \beta_i \eta_{ikj}; \quad (3.3.2.4.9\text{-}1)$$

$$P_{ikj}^{mde} = 0{,}5 k_H k_\psi m_k a_p^{mde} \beta_i \eta_{ikj} \quad (3.3.2.4.9\text{-}2)$$

where k_H = coefficient allowing for a structure height; its value are taken equal to:
1,0 — for structures 100 m high and over;
0,8 — for structures 60 m high and less;
for structures having a height from 60 m to 100 m the values are determined by interpolation between 1,0 and 0,8;
k_ψ = coefficient allowing for shock absorbing properties of structures; its values are taken equal to:
1,0 — for metal structures, and for concrete and reinforced concrete ones at a design seismicity not exceeding a magnitude 8;
0,8 — for concrete and reinforced concrete structures at a design seismicity over a magnitude 8;
m_k = mass of the structure element assigned to a node k (with due regard for the added mass of water);
a_p^{de} and a_p^{mde} = see 3.3.2.4.8;
β_i = dynamic factor corresponding to the i-th tone of natural vibrations of the structure;
η_{ikj} = coefficient of the natural vibrations form of the structure for the i-th form of vibrations.

3.3.2.4.10 The value of the form coefficient η_{ikj} is determined by the formula

$$\eta_{ikj} = U_{ikj} \sum_k m_k \sum_{j=1}^{3} U_{ikj} \cos(\theta_{ikj}) / \sum_k m_k \sum_{j=1}^{3} U_{ikj}^2 \quad (3.3.2.4.10)$$

where U_{ikj} = projections along the j-th directions of the k-th mode shifts for the i-th form of natural vibrations of the structure;
$\cos(\theta_{ikj})$ = cosines of angles between the directions of a seismic effect vector and displacements U_{ikj};
m_k = mass of the structure element assigned to the k-th node (with due regard for the added mass of water).

3.3.2.4.11 The values of dynamic factor β_i are determined by the following formulae (or by the graphs in Fig. 3.3.2.4.11):

$$\left.\begin{aligned} &\beta(T_i) = 1 + \frac{T_i}{T_1}(\beta_0 - 1),\ 0 < T_i \leqslant T_1; \\ &\beta(T_i) = \beta_0,\ T_1 < T_i \leqslant T_2; \\ &\beta(T_i) = \beta_0 T_2^{0,5}/T_i^{0,5},\ T_2 < T_i \end{aligned}\right\} \qquad (3.3.2.4.11)$$

where β_0, T_1, T_2 = parameters whose values are given in Table 3.3.2.4.11;
T_i = natural period of platform's vibrations, s.

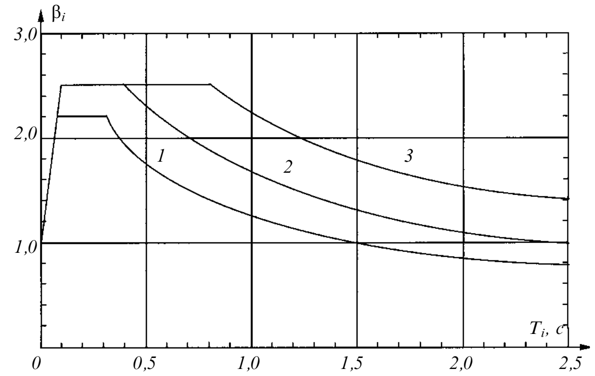


Fig. 3.3.2.4.11 Dynamic factors $\beta(T_i)$:
Curve 1 — for soils of a I category;
Curve 2 — for soils of a I — II, II, II — III, III category for the thickness of an upper soil layer not more than 20 m;
Curve 3 — for soils of a I — II, II, II — III, III category for the thickness of an upper soil layer at least 40 m

Table 3.3.2.4.11

Soil categories by seismic properties	β_0	T_1	T_2
I	2,2	0,08	0,318
I-II, II, II-III, III $H_s \leqslant 20$ M	2,5	0,10	0,41
I-II, II, II-III, III $H_s \geqslant 40$ M	2,5	0,10	0,81

Notes:
1. Categories I — II and II — III meet the cases dealing with soils, which, by its composition, are ranked between the soils of I and II or II and III categories respectively.
2. H_s — thickness of soils with the category I soil underlain.
3. The values of parameters T_1 and T_2 at 20 m < H_s < 40 m, are obtained by a linear interpolation between the values of these parameters at $H_s \leqslant 20$ m and $H_s \geqslant 40$ m.

The value of a product $k_\psi \beta$ is to be at least 0,80, the value of the coefficient k_ψ therewith is determined in accordance with 3.3.2.4.9.

In addition to the calculations made with use of standard functions $\beta(T_i)$, it is allowed to perform the calculations in which reaction spectra of single-component design accelerograms are used.

3.3.2.4.12 The design values of shift components (deformations, stresses or forces) with allowance made for all the forms of natural vibrations of a structure to be considered in the calculation are to be determined by the formula

$$W_j = \sqrt{\sum_{i=1}^{q} W_{ij}^2} \qquad (3.3.2.4.12)$$

where W_j = generalized value of the components of design shifts (deformations, stresses or forces) brought about in the points or sections under consideration by seismic effects;
W_{ij} = generalized value of the components of shifts (deformations, stresses or forces) brought about in the points and sections under consideration by the seismic loadings corresponding to the *i*-th form of natural vibrations;
q = number of natural vibration forms considered in calculations.

3.3.2.4.13 The number of natural vibration forms considered in the calculations according to a linearly spectral theory is selected so that the further refinement of calculation results may be neglected with the increase of that number.

3.3.2.4.14 In calculation of FOP strength with due regard for seismic effects in all the cases of contact of lateral surfaces of a structure with the soil, the influence of seismic forces of the soil on the value of a lateral earth pressure is to be allowed for.

Seismic soil forces in the calculation of a structure are determined from a common dynamic calculation of a system, which includes the structure, base and soil used for backfilling.

3.3.2.4.15 With the availability of cohesionless or weakly cohesive soils (e.g. fine — grained sand) in the FOP base, special emphasis is it be placed on the assessment of potential liquefaction of these soils with the reduction of their resistance to shifting under the action lf seismic loadings.

3.3.2.5 Seabed loadings on a gravity platform bottom.

3.3.2.5.1 The pressures on a bearing surface contacting a foundation soil are to be known for use in the calculations of bottom structures strength. These contact pressures are to be determined with due regard for the shape of a FOP footing and the soil type using the formulae of eccentric compression. Where necessary, these pressures are determined according to the results of a deflected state calculations for a structure — foundation soil system using the methods of mechanics of continua.

3.3.2.5.2 Shear stresses across the contact surface of a FOP footing with a foundation soil caused by vertical forces are usually ignored in strength calculations.

3.3.2.5.3 The maximum design pressure on the bottom from the direction of seabed during a structure operation is determined by multiplication of a mean design pressure by a nonuniformity coefficient dependent on soil properties. The values of the nonuniformity coefficient are given in Table 3.3.2.5.3 for the main types of soils.

Table 3.3.2.5.3

Type of soil surface layer	Value of a nonuniformity coefficient
Silt, clay and loams of sloppy and sloppy-wet consistency at an index of liquidity $I_L > 0{,}75$; sandy loose soils	1,2
Tough and soft clay soils with an index of liquidity $0{,}25 \leqslant I_L \leqslant 0{,}75$, sandy firm soils and sandy soils of medium solidity	1,4
Clay soils of stiff and hard consistency ($I_L < 0{,}25$); very firm sandy soils; fluvial soils; large fragmented soils with a sandy aggregate	2,0
Note: The value of a nonuniformity coefficient is where necessary, refined with due regard for specific design conditions.	

3.3.3 Additional criteria of strength for structures of ice-resistant FOP

3.3.3.1 The ultimate strength criterion for calculation of outer side grillages is defined by the expressions:

$$\sigma \leqslant R_{eH};$$
$$\tau \leqslant 0{,}57 R_{eH} \quad (3.3.3.1)$$

where σ and τ = maximum normal and shear stresses in the elements of girder cross-sections under local ice pressures.

3.3.3.2 The ultimate strength criterion for calculation of separate structural elements of an outer side (plates, stiffeners) is defined by the expression

$$P_p \leqslant P_u/\gamma \quad (3.3.3.2)$$

where P_p = design loading on a structural element due to local ice pressures;
P_u = ultimate loading on a structural element;
γ = ultimate loading safety factor equal to:
1,2 — for special structural elements;
1,1 — for primary structural elements.

3.3.4 Peculiarities of strength calculation for ice strake structures.

3.3.4.1 When calculating structure strength under ice loadings the following loading stages are recommended to be distinguished;

loading of separate structural elements, i.e. plates, stiffeners;

loading of structure grillages;

loading of the structure at large.

In accordance with these stages, the structural elements of an ice strake are to be calculated as specified below.

3.3.4.2 Where a structure is loaded as a whole, the global ice loadings calculated according to 3.3.2.3 are assumed as design. All adverse potential loading cases are to be considered.

Evaluating structure strength, the fashion of global ice loading distribution may be assumed uniform in the front and height of ice formation (level ice, rafted ice or the consolidated part of a ridge).

The calculation is aimed at the check of compliance with the strength criteria by the Formulae (2.4.2.3.1) and (2.4.2.3.2). When evaluating general and local stresses in structural elements, the provisions of 2.5.2, 2.5.3 and 2.5.4 are to be followed.

3.3.4.3 Where structure grillages are under load, the local ice pressures according to 3.3.2.3.11 are assumed as design loadings. In this case, a design contact area A is to be determined as:

$$A = 10 \text{ m}^2, \text{ if } S_{gr} \leqslant 10 \text{ m}^2;$$

$$A = S_{gr}, \text{ if } S_{gr} > 10 \text{ m}^2$$

where S_{gr} = grillage surface area within a rest, m^2.

Based on the grillage calculation, the dimension of web girders are selected and the strength criterion for them (3.3.3.1) is to be met. In determination of stresses, the provisions of 2.5.3 are to be followed.

3.3.4.4 If separate structural members (plates, stiffeners) are loaded, the local ice pressures determined according to 3.3.2.3.11 are assumed as design loadings. In this case, a design contact area A is to be determined as:

$$A = 1 \text{ m}^2, \text{ if } S_p \leqslant 1 \text{ m}^2;$$

$$A = S_p, \text{ if } S_p > 1 \text{ m}^2$$

where S_p = plate surface area or the loaded area of a stiffener.

As an ultimate loading $\overline{P}_u$ is to be considered:

p_u = ultimate pressure on a plate;

Q_u = ultimate loading on a stiffener.

The ultimate pressure p_u on a plate restrained on a rest and loaded by an equidistributed loading across the plate surface is determined by the formula

$$p_u = 4R_r(s/a)^2[1 + 2(a/b)^2] \quad (3.3.4.4\text{-}1)$$

where R_r = design yield stress of a material according to 1.5.1.5, MPa;
s = design plate thickness, m;
a = length of the lesser side of a plate rest, m;
b = length of the longer side of a plate rest, m.

The ultimate loading Q_u on a stiffener restrained at its ends and loaded by an equidistributed loading is determined by the formula

$$Q_u = \frac{16W_u}{l} R_r\overline{Q} \quad (3.3.4.4\text{-}2)$$

where $\overline{Q} \leqslant 1$ = functional coefficient allowing for the effect of shear forces in sections of support;

$$\overline{Q} = \frac{1}{1 + 5{,}77[(W_u/(F_w l^2))(l - 0{,}5a)]^2};$$

F_w = design area of a stiffener web cross-section, m^2;
W_u = ultimate section modulus with due regard for an effective flange, m^3;
a = spacing between stiffeners, m;
l = span of a stiffener between its supports, m.

For plates and stiffeners, the strength criteria of 3.3.3 are to be met.

3.4 FOP REINFORCED AND STEEL CONCRETE STRUCTURES

3.4.1 General.

3.4.1.1 This Section of the Rules sets the basic requirements for design and construction of FOP hulls made wholly or in part (of a composite modification) of the following materials based on an ordinary concrete without prestressing:

reinforced concrete consisting of a concrete and metal bar reinforcement dispersedly arranged in it in accordance with a calculation and structural requirements;

steel concrete consisting of a concrete and metal plate reinforcement arranged on exterior surfaces of a structural element and attached to the concrete with adequate strength and rigidity in accordance with design and structural requirements;

composite reinforced concrete, i.e. the material occupying an intermediate position between the above two in which, additionally to a concrete, metal plate reinforcement is attached to one or the both exterior surfaces of a structural element in order to improve tightness and to increase carrying capacity of the last.

Hereinafter, steel concrete structures with exterior plate reinforcement and composite structures are called in MODU/FOP Rules as steel concrete structures and appropriate refinements are made where necessary.

3.4.1.2 Design of prestressed reinforced and steel concrete structures of FOP hulls may be executed according to specialized regulatory documents approved by the Register or in consultation with it.

3.4.1.3 In design of reinforced concrete, steel concrete and composite structures of FOP hulls, the provisions of the Rules for the Construction of Sea-Going Reinforced Concrete and Composite Ships and Floating Docks may be used where appropriate.

3.4.2 Loadings.

3.4.2.1 The design values of loadings on reinforced and steel concrete structures of FOP hulls due to various types of effects at their potential combinations are determined in accordance with the provisions of 2.3, 3.3.1 and 3.3.2.

3.4.2.2 The elements of massive steel concrete structures whose exterior plate reinforcement acts as forms, and also of precast-cast-in-situ reinforced concrete structures are to be designed for two stages of structure functioning:

prior to reaching the preset strength of a freshly laid concrete under its gravity and other loadings relevant for this stage of structure construction;

after reaching the preset strength of concrete relevant for operational loadings.

3.4.3 Key design requirements.

3.4.3.1 Reinforced and steel concrete structures are to meet the requirements of the calculation for carrying capacity (limit states of the 1st group) and fitness for normal operation (limit states of the 2nd group).

When the requirements of calculations for limit states are fulfilled, it is practically to be excluded:

for limit states of the 1st group:

brittle and ductile failures, loss of form buckling strength, fatigue failure (calculation for structures endurance under repeated loadings). etc.;

for limit states of the 2nd group:

cracking in the concrete of crack-resistant structures, excessive opening of cracks in the concrete of structures for which cracking is allowable under operational conditions, excessive displacements, etc.

3.4.3.2 Reinforced and steel concrete structures are to be designed so that the general safety requirement stated in 2.4.1.1 may be fulfilled during the FOP entire life cycle. In this case, safety factors η are to be taken according to Table 2.4.2.5 as for the strength criterion (2.4.2.3.1).

3.4.4 Materials.

3.4.4.1 Concrete and its components.

3.4.4.1.1 The concrete of reinforced and steel concrete structures of FOP hulls is to meet the requirements of national standards, the Rules for the Construction of Sea-Going Reinforced Concrete and Composite Ships and Floating Docks and the requirements of this Section.

3.4.4.1.2 For reinforced and steel concrete structures, structural concretes are to be used:

normal-weight concrete, air-hardened or heat-treated at an atmospheric pressure, having an average density over 2300 up to 2500 kg/m^3 inclusive;

fine-grained concrete (Abram's fineness of sand is over 2,0), air-hardened or heat-treated at an atmospheric pressure.

It is allowed to use:

light-weight dense and fine aggregate concrete having an average density over 1800 kg/m^3;

special (stressing) concrete (in consultation with the Register).

3.4.4.1.3 In design of concrete compositions and procedures of concrete making and placement the following peculiarities are to be taken into account:

complexity of the configuration of the structure volume to be filled;

work performance under conditions of a Northern climatic zone;

concreting afloat;

concrete placement with concrete pumps;

concrete placement without vibration effects;

improved requirements for density, freezing resistance and water tightness in the zones of ice and wave loading effects.

3.4.4.1.4 For hull structures with high requirements for strength, water tightness and freezing resistance, for instance, for exterior structures located within an alternating waterline, it is necessary to provide the use of surfactant admixtures and micro fillers. The optimum content of admixtures and fillers is to be determined experimentally while selecting concrete compositions.

3.4.4.1.5 In conformity with the type, purpose and operational conditions the concretes of the following classes and brands are to be used for special and main reinforced and steel concrete structures of FOP hulls:

.1 compressive strength classes meeting the value of guaranteed strength, in MPa, with the probability of exceedance 0,95:

normal-weight concrete: B30, B35, B40, B45, B50, B55 and B60 (if properly justified and approved by the Register, it is allowed to use the concretes of compressive strength classes B70 and B80);

fine-grained concrete: B30, B35 and B40;

.2 freezing resistance brands: F100, F150, F200, F300, F400, F500 and F600 specified according to the data in Table 3.4.4.1.5.2;

Table 3.4.4.1.5.2

Operational conditions	Freezing resistance brand of a concrete at the number of repeated cycles of freezing and thawing per year				
	up to 50 incl.	over 50 up to 75	over 75 up to 100	over 100 up to 150	over 150 up to 200
Moderate	F50	F100	F150	F200	F300
Severe	F100	F150	F200	F300	F400
Very severe	F200	F300	F400	F500	F600

Notes: 1. Operational conditions feature the monthly average air temperature of the coldest month: moderate — over −10 °C ; severe — from −10 °C to −20 °C; very severe — below −20 °C.
2. For exterior structures under operational conditions at the number of repeated cycles of freezing and thawing in winter over 200 (the monthly average air temperature of the coldest month is below −30 °C, salt content is from 20 g to 36 g per 1 l of water) the freezing resistance brand of a concrete is specially to be substantiated and specified in each particular case on the basis of the analysis of specific operational conditions, and approved by the Register.

.3 watertightness brands for water-contacted reinforced concrete structures: W6, W8, W10, W12 and above specified in conformity with the head gradient determined as the ratio of a maximum head to the structure thickness (in meters), and with the water temperature, in accordance with Table 3.4.4.1.5.3.

Table 3.4.4.1.5.3

Water temperature, °C	Watertightness brand of concrete at the head gradient		
	over 5 up to 10	over 10 up to 20	over 20 up to 30 incl.
Up to 10 inclusive	W4	W6	W8
Over 10 up to 30 incl.	W6	W8	W10
Over 30	W8	W10	W12

Notes:
1. For structure with the head gradient over 30 the watertightness brand of concrete is to be W16 and above.
2. For exterior structures exposed to seawater and its splashes, and also being in contact with ice formations and a seabed soil the watertightness brand of concrete is to be not below W8.

3.4.4.1.6 For ancillary hull structures it is allowed to use light-weight concretes of compressive strength classes: B30, B35 and B40.

3.4.4.1.7 For FOP massive hull structures, for instance, steel concrete floor structures having thickness over 1 m, provided that the concrete is largely used as a solid ballast and involved in carrying only local loadings, it is allowed to use normal-weight concretes of lower compressive strength classes: B20 and B25.

3.4.4.1.8 In design of FOP, strength classes on the basis of tension may be established if specially substantiated.

3.4.4.1.9 It is not allowed to use a fine-grained concrete without an experimental justification for structures subjected to a many times repeated loading.

3.4.4.1.10 In design of reinforced and steel concrete structures the compressive strength class of concrete is established at 28 days. In all cases, external forces and other effects on the concrete are allowed only when they reach at least 70 per cent of the strength appropriate for the strength class adopted.

3.4.4.1.11 In order to grout joints and element assemblies of precast structures the concretes of strength classes are to be used, and freezing resistance and water tightness brands, which are not interior to those, adopted for abutting elements.

3.4.4.1.12 In design of FOP the values of characteristic strength of concrete in axial compression (prism strength) R_{bn} and in axial tension R_{btn}, the values of design strength of concrete in compression and tension for the 1st group limit states (as to a carrying capacity) R_b and R_{bt} and for the 2nd group limit states (as to serviceability) R_{b2} and R_{bt2}, determined by the division of the values of characteristic strength by the relevant concrete reliability coefficients in compression and tension, and initial moduli of elasticity for an air-hardened concrete in compression and tension depending on the compressive strength classes are to be adopted according to Table 3.4.4.1.12.

3.4.4.1.13 The values of design strength of concrete for the 1st group limit states R_b and R_{bt} should be entered into a calculation with due regard for the coefficients of operational conditions γ_{bi}, whose values are given in Table 3.4.4.1.13-1. Specify-

Table 3.4.4.1.12

Concrete design class	Characteristic strength of concrete, design strength of concrete for the 2nd group limit states, MPa		Design strength of concrete for the 1st group limit states, MPa		Initial modulus of elasticity in concrete compression and tension $E_b \cdot 10^{-3}$, MPa
	Axial compression (prism strength) $R_{bn} = R_{b2}$	Axial tension $R_{btn} = R_{bt2}$	Axial compression R_b	Axial tension R_{bt}	
Normal-weight concrete					
B20	15,0	1,40	11,5	0,90	27,0
B30	22,0	1,80	17,0	1,20	32,5
B40	29,0	2,10	22,0	1,40	36,0
B50	36,0	2,30	27,5	1,55	39,0
B60	43,0	2,50	33,0	1,65	40,0
Light-weight and fine-grained concrete					
B30	22,0	1,80	17,0	1,20	26,0/19,5[1]
B40	29,0	2,10	22,0	1,40	28,5/21,0[1]

[1]In numerator — a fine-grained concrete, and in denominator a light-weight concrete.

Note: When intermediate compressive strength classes of concrete are used, the values of parameters are determined by linear interpolation.

Table 3.4.4.1.13-1

Nos.	Factors leading to introduction of the coefficient of operational conditions for concrete	Coefficient of operational conditions for concrete	
		Symbol	Value
1	Many times repeated loading	γ_{b1}	See Table 3.4.4.1.13-2
2	Concreting in vertical position with the height of a concreting layer over 1,5 m	γ_{b2}	0,85
3	Repeated freezing and thawing	γ_{b3}	
	a) in a water saturation state at the design winter temperature of outdoor air:		
	below −40 °C		0,70
	below −20 °C down to −40 °C inclusive		0,85
	below −5 °C down to −20 °C inclusive		0,90
	−5 °C and over		0,95
	b) in conditions of random water saturation:		
	below −40 °C		0,90
	−40 °C and over		1,00
4	Concrete in reinforced concrete structures	γ_{b4}	1,1

Notes:

1. Coefficients of operational conditions for items 1,3 and 4 are to be taken into account in calculating the values of design strength R_b and R_{bt}, and for item 2, in the calculation of R_b only.
2. For structures under a many times repeated loading the coefficient γ_{b1} is considered only in the calculation for endurance and when cracks in concrete are formed.
3. When the freezing resistance brand of the concrete, as compared with that required according to Table 3.4.4.1.5.2, is exceeded, the coefficient γ_{b3} may be increased by 0,05 for each step of excess, but it may not be over 1,0.
4. Coefficients of operational conditions of the concrete are introduced independently of one another, but their product is to be not less than 0,45.

ing the values of design strength of concrete for the 2nd group limit states R_{b2} and R_{bt2} only one coefficient of operational conditions γ_{b1} of concrete, according to Table 3.4.4.1.13-2, is taken into account.

Table 3.4.4.1.13-2

Humidity state of concrete	Coefficient of operational conditions of concrete at many times repeated loadings and a coefficient of cycle asymmetry ρ_b equal to:						
	0 - 0,1	0,2	0,3	0,4	0,5	0,6	0,7
Natural humidity	0,75	0,8	0,85	0,9	0,95	1,00	1,00
Water saturation	0,50	0,60	0,70	0,80	0,90	0,95	1,0

Note. A coefficient of cycle asymmetry ρ_b is equal to the ratio of the least stress in concrete to the largest one during the cycle of loading change.

3.4.4.1.14 For concretes subjected to repeated freezing and thawing the values of an initial modulus of elasticity given in Table 3.4.4.1.12 are to be multiplied by the coefficient of operational conditions γ_{b3} assumed according to Table 3.4.4.1.13-1.

3.4.4.1.15 When calculating reinforced and steel concrete structures for endurance, nonelastic deformations of concrete in the compressed zone are to be taken into account by the reduction of a modulus of elasticity adopting a steel to concrete reduction coefficient according to Table 3.4.4.1.15.

Table 3.4.4.1.15

Compressive strength class of concrete	B20	B30	B40	B50	B60
Reduction coefficient ν'		23		18	

3.4.4.1.16 The coefficient of linear thermal deformation d_{bt} of concrete is to be assumed in calculations equal to $1/10^{-5}$°C^{-1}.

3.4.4.1.17 The initial coefficient of lateral deformation μ of concrete (Poisson's ratio) is assumed equal to 0,2.

3.4.4.1.18 The shear modulus of concrete is assumed equal to 0,4 of appropriate values for initial moduli of elasticity of concrete specified in Table 3.4.4.1.12.

3.4.4.2 Reinforcement.

3.4.4.2.1 As untensioned bar and wire reinforcement is to be used:

.1 bar reinforcement of Class A-III — for longitudinal and transverse reinforcement;

.2 bar reinforcement of Class A-II — for transverse reinforcement and for longitudinal one where the other types of reinforcement can not be used due to operational conditions;

.3 bar reinforcement of Class A-I and reinforcing wire of Class B_p-I — for longitudinal and transverse reinforcement.

Reinforcement of Class A-III, 10 to 40 mm in diameter, in exterior structures at the temperature not lower than −40 °C may be used only for tied cages and fabrics (without welding).

3.4.4.2.2 For FOP hull structures operating under severe and very severe climatic conditions (see 3.4.4.1.5) it is not allowed to use bar reinforcement over 16 mm in diameter made of semikilled steel.

3.4.4.2.3 The characteristic strength of bar and wire reinforcement for the classes specified in 3.4.4.2.1 and the design strength of reinforcement for limit states of the 1st and 2nd groups (see 3.4.3.1) depending on the loading nature, and also moduli of elasticity and relative elongations are given in Table 3.4.4.2.3.

3.4.4.2.4 The characteristic and design strength of steel plate reinforcement for composite reinforced concrete structures and steel concrete structures are determined in accordance with 1.5.1.5.

3.4.4.2.5 The design strength of reinforcement for reinforced concrete structures, steel concrete and composite structures compression as to limit states of the 1st group is to be assumed in all cases not more than $R_{SC} = 400$ MPa.

3.4.4.2.6 The values of design strength of reinforcement RS, RCS and RSW for limit states of the 1st group are used in a calculation with due regard for coefficients of operational conditions γ_S and γ_{Si} whose values are given in Tables 3.4.4.2.6-1 and 3.4.4.2.6-2

Table 3.4.4.2.6-1

Factor leading to introduction of the coefficient of operational conditions for bar reinforcement	Coefficients of operational conditions for bar reinforcement γ_S
Reinforced concrete members	1,05
Composite reinforced concrete members	1,0
Many times repeated loadings at a coefficient of cycle asymmetry ρ_S:	
-1,0 — 0	0,6 [1]
0 — 0,4	0,7 [1]
0,4 — 0,8	0,9 [1]
0,8 — 1,0	1,0 [1]

[1] Where welded joints of reinforcement of the following types are available:
contact butt joint without mechanical dressing;
butt joint made in a weld pool on a steel backing; the weld pool length is to be three or more diameters of the least abutting bar;
twin-symmetrical strap butt joint.

Note. The coefficient of cycle asymmetry ρ_S is equal to the ratio of the least stress in reinforcement to the largest one during the cycle of loading change.

Tables 3.4.4.2.6-2

Factor leading to introduction of the coefficient of operational conditions for plate reinforcement	Coefficients of operational conditions for plate reinforcement γ_{Si}
Plate reinforcement without special treatment of concrete-contacted surface and without anchors	0,5
Plate reinforcement with the ribbed surface of contact with concrete, without anchors	0,7
Plate reinforcement anchored in concrete according to the calculation in compliance with the requirements of 3.4.6.5	0,9

Table 3.4.4.2.3

Reinforcement class	Diameter, mm	Characteristic tensile strength (yield stress), design tensile strength for the 2nd group limit states, MPa, $R_{Sn} = R_{S2}$	Design strength for the 1st group limit states, MPa			Modulus of elasticity *E, MPa*	Relative elongation, %	Bending test in cold state (*c* — mandrel thickness, *d* — bar diameter)
			Tension		Compression			
			Longitudinal R_S	Transverse (clamps and web bars) R_{SW}	R_{SC}			
A-I	6÷40	235	225	175	225	$2{,}05/10^5$	⩾25	180° $c = 0{,}5d$
A-II	6÷40	295	280	225	280	$2{,}05/10^5$	⩾19	180° $c = 3d$
A-III	6÷40	390	355	285[1]	355	$2{,}00/10^5$	⩾14	90° $c = 3d$
B_p-I	3	410	375	270	375	$1{,}70/10^5$	—	—
	4	405	365	265	365	$1{,}70/10^5$	—	—
	5	395	360	260	360	$1{,}70/10^5$	—	—

[1] In welded cages, transverse bars (clamps) in Class A-III reinforcement whose diameter is less than a third of the diameter of longitudinal bars, the values are taken equal to 255 MPa.

3.4.5 Requirements for design of FOP hulls of composite concrete-based materials.

3.4.5.1 Cross-section dimensions of reinforced, composite reinforced and steel concrete members of FOP hull structures are to be determined by calculation reasoning from the conditions of strength, cracking resistance or restrictions on cracks opening.

In all cases therewith the total sectional area of longitudinal principal bar and plate tension reinforcement is to be not less than 0,4 per cent of a concrete section area.

3.4.5.2 The thickness of a protective layer for the concrete of reinforced concrete structures is to be adopted not less than:

.1 on the surface exposed to water effects:

50 mm — for principal reinforcement;

30 mm — for distribution reinforcement and clamps;

.2 on surfaces not exposed to sea water effects:

30 mm or at least a bar diameter — for principal reinforcement;

20 mm or at least a bar diameter — for distribution reinforcement and clamps.

3.4.5.3 A reinforcement diameter for FOP sides, decks and bottom is to be at least 12 mm, and inside internal wall members, at least 8 mm.

3.4.5.4 The minimum thickness of plate reinforcement is to be 10 mm for composite reinforced concrete structures, and 15 mm for steel concrete structures.

3.4.5.5 The thickness of reinforced concrete grillages of a bottom and sides within the range of an alternating water level, direct ice effects and in an underwater part is recommended to be at least:

0,6 m to 0,8 m, for hulls in the form of a cylindrical or conic shell, and for composite and cast-in-situ hulls;

0,4 m to 0,5 m — for hulls of cellular structure.

3.4.5.6 Bar reinforcement for reinforced and composite reinforced structures is to be designed in the form of reinforced trusses, welded cages and fabrics. The types of reinforced structures are to provide for the possibility of mechanized concrete supply, its thorough handling or self-consolidation.

3.4.5.7 All the carrying parts of a FOP hull are to be free of abrupt changes of cross-sections, and of curvatures. The cross-section of reinforcement is reasonably to change through reduction of the bars diameter with no change of their quantity.

It is allowed to connect in one section of a structure not more than 30 per cent of bars in a tension zone, and not more than 50 per cent, in a compression zone.

3.4.5.8 In design of reinforcement the measures ensuring the reliable anchorage of its ends are to be provided. The anchorage of reinforcement is to be effected by welding of a curtailed bar to transverse distribution reinforcement or by bar lengthening from a place where it is needed by a calculation for at least 30 diameters for tension deformed reinforcement, and for at least 20 diameters for compression one.

3.4.5.9 Angle joints of flat members of FOP hulls are to be designed to ensure equal or greater strength of joined members. In reinforced and composite reinforced concrete structures, opposing reinforcement in side-deck angle joints is to be welded or extended from one slab into another for at least 15 reinforcement diameters. In side-bottom angle joints provision is to be made for sections thickening by at least 1,5 times or bevelling of corners of inner or inner and outer assembly surfaces with installation of additional reinforcement along bevel surfaces.

On T and cross joints, opposing reinforcement is to be welded or extended from one slab into another in sections of at least 15 reinforcement diameters long over their outline,

3.4.5.10 In steel concrete structures of FOP hull grillages it is recommended to provide for transverse members of sheet steel (diaphragms) between exterior (outer and inner) steel plates, in angle bottom-side and side-deck joints it is to be provided for bevelling of inner assembly surfaces and for gusset plates (brackets), their welding to inner surfaces of joined flat structures. The spacing of gusset plates is to be not less than the thickness of the thinner among the members. The gusset plate metal thickness is to be not more than that of a lining.

3.4.5.11 In design of composite reinforced and steel concrete members of FOP hulls it is to be provided for measures ensuring the joint operation of plate reinforcement in concrete according to the calculation in compliance with the requirements of 3.4.6.5; the use of exterior plate reinforcement with a profiled surface is also recommended.

3.4.5.12 In selection of the rest and anchor design one is to proceed from simplicity and reliability of their securing to plate reinforcement by means of continuous or intermittent welding.

It is allowed to use various structural types of members and anchors, namely: rigid and flexible rests, various anchors including of reinforcement bars, as well as combined members like the loop anchors of reinforcement bars welded to rigid rests, etc.

N o t e . The rests or anchor members of the cuts of rolling sections with their axis parallel to the exterior steel plate plane and perpendicular to a shear force are considered as rigid if stiffeners, brackets, etc. are available, and as flexible if the last are lacking.

3.4.5.13 In sections of contact surfaces remoted from supports it is preferable to use flexible or combined rests and anchors which, to a lesser extent, impact the process of cracking in concrete.

3.4.5.14 Outer plate reinforcement is to be securely anchored in concrete to prevent the buckling (buckling between anchors) under compression stresses in bending of a steel concrete grillage. In order to ensure reinforcement buckling strength up to the yield stress, the anchors spacing is to be determined in accordance with the standards for steel structures design and assumed to be not more than 25δ thicknesses for normal strength steel and not more than 20δ thicknesses for higher strength steel.

3.4.5.15 The attachment of rests, anchors, etc. to a steel part are to be computed in accordance with the instructions on the calculation of welded steel structure joints of the Rules for the Classification and Construction of Sea-Going Ships. In this case, the values of loadings determined according to 3.4.6.5 are used in the calculation.

3.4.5.16 In design of rests and anchors the following conditions are to be fulfilled:

a clear distance between rigid rests is to be at least 3,5-fold height of the design area of concrete bearing by the rest;

the design of rigid rests is to ensure uniform concrete deformations across a bearing area, i.e. there are not to be any corners or other convex surfaces on crushing surfaces, which may cause concrete cleavage. When the surface transferring pressure of the rest onto concrete is convex, the zone of local concrete compression by the rest is to be reinforced.

3.4.6 Calculation for strength and endurance.

3.4.6.1 Basic design provisions.

3.4.6.1.1 In calculation of FOP hull the internal forces due to general and local loadings, as well as due to forced movements (as a consequence of the change of a temperature, concrete moisture, etc.) are to be determined following the instructions of 2.5.1 and 2.5.2 with due regard for inelastic behaviour of loaded structures, caused by concrete cracking and creep and by a non-linear relationship between stresses and material deformations, according to methods approved by the Register.

In the cases when the calculation methods with due regard for inelastic behaviour are not developed or the calculation is carred out at the intermediate stage of platform design, forces in cross-sections are to be determined assuming an elastic operation of structures. The height of a compressive zone of the concrete in them therewith is determined basing on a plane-sections hypothesis. In non-crack-resistant structures the operation of tensile concrete is ignored and the form of a concrete stress diagram within the compression zone of sections is assumed as triangular.

3.4.6.1.2 Calculations of the stress state of members in bending basing on the preconditions specified in 3.4.6.1.1 are applicable when the ratios of a working (effective) height of a member to the distance between the points of a zero bending moment are less than 1/2 or the ratio of a working height to a span is less than 1/3 . If these ratios exceed the above values, the members are to be calculated as deep beams.

3.4.6.1.3 The geometric characteristics of cross-sections of members are determined for sections brought to one material. The areas of design cross-sections transformed to concrete or steel are determined by the formulae:

$$F_{bl} = \Sigma(F_b + F_s E_s/E_b); \quad (3.4.6.1.3\text{-}1)$$

$$F_{sl} = \Sigma(F_s + F_b E_b/E_s) \quad (3.4.6.1.3\text{-}2)$$

where F_b and F_s = cross-sectional areas of concrete and longitudinal reinforcement of the member in question, respectively;

E_b and E_s = initial moduli of elasticity for concrete and steel.

3.4.6.1.4 If the cross-section of a structure under consideration includes a compression steel member, that may lose its buckling strength, the section area relevant to it is to be included into a transformed area with a reduction factor (see 2.5.2)

3.4.6.1.5 In determination of the main tension, compression and shear stresses in concrete, the structure sections transformed to the concrete assuming the elastic operation of materials with due regard for the concrete in a tensile zone are taken into account.

3.4.6.1.6 In analytical assessments of the deflected state of reinforced and steel concrete grillages, for determination of internal forces in grillage sections it is recommended to use the design diagram of a plate with due regard for the provisions of 3.4.6.1.2 to 3.4.6.1.5.

3.4.6.1.7 Calculations for members strength under the action of a bending moment and an axial force should be performed for sections normal to a longitudinal axis and also inclined to it along the most critical directions.

3.4.6.1.8 Ultimate resistance forces in bending in the section normal to the longitudinal axis of *a* member are to be determined following the preconditions:

concrete resistance to tension is assumed equal to zero;

concrete stresses in a compression zone are adopted equal to a design strength R_b, and the form of compression stress diagram is taken as rectangular;

tension and compression stresses in reinforcement are accepted as not exceeding the design ones.

3.4.6.1.9 In calculation of reinforced concrete and steel concrete members for combined torsion and bending the following condition is to be observed:

$$M_t \leqslant 0{,}1R_b b^2 h \qquad (3.4.6.1.9\text{-}1)$$

where M_t = torque moment;
b, h = lesser and larger dimensions of member sides, respectively.

In this case the value of R_b for the concretes whose classes are higher than Class B39 is taken as for the Class B30 concrete.

The calculation of three-dimensional reinforced and steel concrete structures for torsion at intermediate stages of platform's design is allowed to perform assuming an elastic operation of a structure with regard to the tensile concrete. The maximum shear stresses in concrete therewith are to meet the condition

$$\tau_{\max} \leqslant 1{,}86R_{btn} \qquad (3.4.6.1.9\text{-}2)$$

where R_{btn} = characteristic strength of concrete to axial tension.

3.4.6.1.10 When a sizable concentrated loading is applied to the limited area of a member, the check of its local strength for bearing, forcing through, breaking away, etc. is to be performed.

3.4.6.2 Calculation of members strength in sections normal to the longitudinal axis of the member.

3.4.6.2.1 The calculation of members strength in sections normal to the longitudinal axis of the member is to be conducted in accordance with 3.4.3.2 and 3.4.6.1.8 observing the condition

$$\xi = x/h_0 < \xi_R \qquad (3.4.6.2.1\text{-}1)$$

where ξ, x = relative and true height of the compressed zone of concrete;
h_0 = working section height equal to the distance from the resultant of forces in tensile reinforcement the compression face of a concrete section;
ξ_R = boundary height of the compression zone to be accepted according to Table 3.4.6.2.1.

Table 3.4.6.2.1

Reinforcement class	Boundary values of ξ_R for concrete class	
	B20, B25, B30	B35 and over
A-I	0,65	0,60
A-II,B_p-I, A-III	0,60	0,50

Sections with double bars (in tensile and compression zones in bending) are to meet the condition

$$M < R_b S_0 \qquad (3.4.6.2.1\text{-}2)$$

where M = bending moment acting in a section;
R_b = design strength of concrete in compression for the 1st group limit states;
S_0 = static moment of the entire cross-sectional area of concrete (less a protective layer in a tensile zone) about the centre of gravity of a section of tensile reinforcement.

3.4.6.2.2 The calculation of sections of flexural concrete members of any symmetric form is to be performed by the formulae:

$$\Phi = M;\ R = \gamma_b R_b S_b + \gamma_s R_{sc} S_s; \qquad (3.4.6.2.2\text{-}1)$$

$$\gamma_s R_s F_s - \gamma_s R_{sc} F_s' = \gamma_b R_b F_b. \qquad (3.4.6.2.2\text{-}2)$$

For a rectangular symmetrical section (see Fig. 3.4.6.2.2-1)

$$S_b = bx(h_0 - 0{,}5x);\ S_s = F_s'(h_0 - a');\ F_b = bx.$$

If the height of a compression zone determined without regard for compression reinforcement is less than the double thickness of a protective layer, i.e. less than $2a'$ (see Fig. 3.4.6.2.2-1), the compression reinforcement may be ignored in calculation.

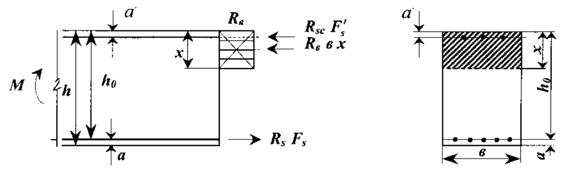


Fig. 3.4.6.2.2-1 Diagram of forces on the section normal to the longitudinal axis of a flexural reinforced concrete member in calculation of its strength

The calculation of flexural composite reinforced concrete members should be performed without considering the compliance of the connective seam of plate reinforcement with the concrete according to the formulae (Fig. 3.4.6.2.2-2):

$$\Phi = M;\ R = \gamma_b R_b bx(h_0 - 0{,}5x) + \gamma_s R_{sc} F_s'(h_0 - a') +$$

$$+ \gamma_{si} R_{si} F_{si}'(h_0 + 0{,}5d_{si}); \qquad (3.4.6.2.2\text{-}3)$$

$$\gamma_s R_s F_s - \gamma_s R_{sc} F_s' + \gamma_{si} R_{si} F_{si} - \gamma_{si} R_{si} F_{si}' = \gamma_b R_b bx. \qquad (3.4.6.2.2\text{-}4)$$

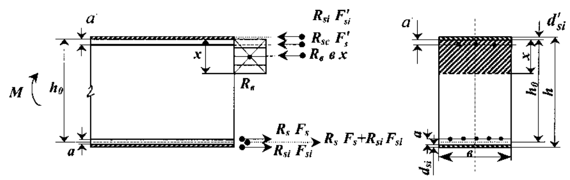


Fig. 3.4.6.2.2-2 Diagram of forces on the section normal to the longitudinal axis of a flexural composite reinforced concrete member in calculation of its strength

Where the cross-sectional area of compression reinforcement in the section of a composite reinforced concrete member is equal or more than the cross-sectional area of tensile reinforcement the design bending strength of the section is determined by the formula

$$R = (\gamma_{si} R_{si} F_{si} + \gamma_s R_s F_s)(h_0 + 0{,}5d'_{si}) \qquad (3.4.6.2.2\text{-}5)$$

where R = design bending strength of section;

S_b and S_s = static moments of the section area of a compression concrete zone, and of the section area of compression reinforcement respectively, about the centre of gravity of tensile reinforcement;
F_s, F'_s, F_{si} and F'_{si} = cross-sectional areas of tensile and compression bar and plate reinforcement, respectively;
R_b, R_s, R_{sc} and R_{si} = design strength of concrete, tensile and compression bar and plate reinforcement, respectively (see 3.4.4);
γ_b, γ_s, γ_{si} = coefficients of operational conditions of concrete, bar and plate reinforcement, respectively, accepted according to Tables 3.4.4.1.13-1, 3.4.4.2.6-1 and 3.4.4.2.6-2.

The calculation of steel concrete members is to be performed according to the Formulae (3.4.6.2.2-3) to (3.4.6.2.2-5) assuming $F_s = F'_s = 0$.

3.4.6.2.3 The calculation of eccentrically compression and tensile members with a rectangular form cross-section, and also the calculation of members having T and double —T cross-sections in bending, eccentrical compression and tension are recommended to perform according to the formulae of the Rules for the Construction of Sea-Going Reinforced Concrete and Composite Ships and Floating Docks on the basis of design characteristics of materials and design coefficients accepted in these Rules with regard to the provisions of 3.4.6.2.1 and 3.4.6.2.2.

3.4.6.3 Calculation of member strength in sections inclined to the longitudinal axis of the member under the action of a transverse force.

3.4.6.3.1 When calculating the member section strength in bending, eccentrical compression and tension for the action of a transverse force the following condition is to be observed:

$$Q \leqslant 0{,}25\eta\gamma_{b4}R_b b h_0 \quad (3.4.6.3.1)$$

where b = minimum sectional width of a member;
η = safety factor (see 2.4.1.1 and 3.4.3.2).

3.4.6.3.2 The calculation of member sections may be ignored if the following condition is fulfilled:

$$Q \leqslant \eta\delta(0{,}5 + 2\xi)R_{bt} b h_0 \quad (3.4.6.3.2)$$

where $\delta = 2/(1 + M/Qh_0)$, but not more than 1,5 and not less than 0,5;
M, Q = forces in a normal section through the end of a sloping section in the compression zone;
ξ = relative height of the compression zone being determined:
for flexural members —

$$\xi = \mu R_s/R_b;$$

for eccentrically compression and tensile members with a large eccentricity when $S_b \leqslant 0{,}8S_0$, —

$$\xi = \mu R_s/R_b \pm N/bh_0R_b;$$

μ = coefficient of reinforcing determined as the ratio of the section area of a longitudinal reinforcement in the tensile zone of the section to the cross-sectional area bh_0 of the member.

Note. The signs "plus" and "minus" are to be used for eccentrically compression and tensile members, respectively.

3.4.6.3.3 For eccentrically tensioned members with a small eccentricity when $S_b > 0{,}8S_0$ the strength calculation of the sections inclined to the longitudinal axis of the member is compulsory in all the cases when a transverse force acts.

3.4.6.3.4 The calculation of transverse reinforcement in the sloping section of a reinforced, composite reinforced and steel concrete member (Fig. 3.4.6.3.4) is to be performed by the following formulae:

for flexural, eccentrically compressed and tensioned with a large eccentricity members —

$$\Phi = Q,\ R = \Sigma\gamma_s R_{sw} F_{sw} + \Sigma\gamma_{si} R_{si} F_{swi} + \gamma_b\delta(0{,}5 + 2\xi)R_{sw} b h_0; \quad (3.4.6.3.4\text{-}1)$$

for eccentrically tensioned members with a small eccentricity —

$$\Phi = Q,\ R = \Sigma\gamma_s R_{sw} F_{sw} + \Sigma\gamma_{si} R_{si} F_{swi} \quad (3.4.6.3.4\text{-}2)$$

where $\Sigma\gamma_s R_{sw} F_{sw}$ и $\Sigma\gamma_{si} R_{si} F_{swi}$ = sums of forces in all transverse bars (clamps) and transverse plate members in a sloping section;
F_{sw}, F_{swi} = cross-sectional areas of transverse bar and plate reinforcement;
ξ = relative height of a sectional compression zone according to 3.4.6.3.2;
γ_b, γ_s, γ_{si} = coefficients of operational conditions of concrete and reinforcement taken according to Tables 3.4.4.1.13-1, 3.4.4.2.6-1 and 3.4.4.2.6-2.

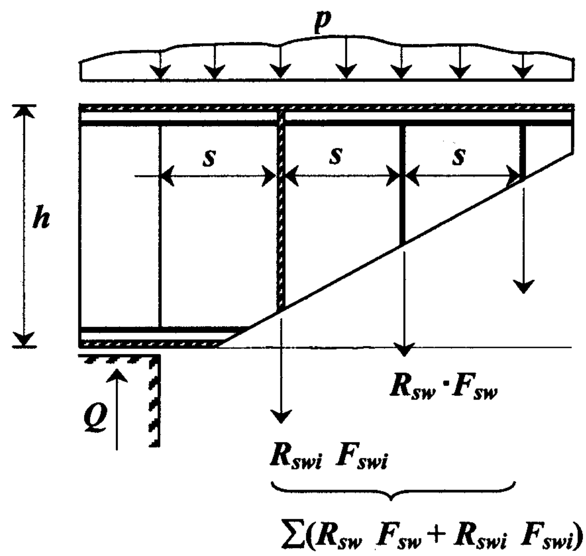


Fig. 3.4.6.3.4 Diagram of forces in the section inclined to the longitudinal axis of a composite reinforced concrete member in calculation of its strength for the action of a transverse force

3.4.6.3.5 In calculation of the plate members of reinforced concrete structures, having the height-design length ratio $h_0/l \leqslant 1/3$, for the action of a transverse force in the plate plane the conditions of (3.4.6.1.9-1) and (3.4.6.1.9-2) are to be met. In this case the maximum shear stresses are determined in accordance with the provisions of 3.4.6.1.5. The strength of transverse reinforcement (clamps) and longitudinal reinforcement distributed over the section height is to be checked in this case for the action of main tensile stresses in way of the neutral axis of the section.

3.4.6.3.6 The distance between transverse members (see Fig. 3.4.6.3.4), in case of inclined bars, between the end of the preceding and the beginning of the following bend which is the nearest to a support, is to be not less than the value of $s_{\max}$ determined by the formula

$$s_{\max} = \eta(0{,}5 + 2\xi)\gamma_b R_{bt} b h_0^2 / Q_1 \qquad (3.4.6.3.6)$$

where $Q_1 = R$ being determined by the Formula (3.4.6.3.4-1).

3.4.6.4 Calculation of reinforced and steel concrete structures for endurance.

3.4.6.4.1 The calculations of structure members for endurance are to be performed in all the cases when the number of loading change cycles is equal to $2/10^6$ and more over the entire design period of the FOP operation.

3.4.6.4.2 The calculation of structure members for endurance is to be performed, assuming the elastic operation of materials, by way of comparison of stresses in extreme fibres of concrete and of stresses in tensile bar and plate reinforcement with the design strength of materials adopted with the relevant coefficients of operational conditions (see Tables 3.4.4.1.13-1, 3.4.4.2.6-1 and 3.4.4.2.6-2).

3.4.6.4.3 In crack-resistant members, stresses in extreme concrete fibres and in bar and plate reinforcement are determined for transformed sections (see 3.4.6.1.3) with regard to the operation of entire section concrete and to the provisions of 3.4.4.1.15.

In crack-nonresistant members the geometric characteristics of sections are determined for transformed sections without regard to the concrete of a tensile zone and with regard to the provisions of 3.4.4.1.15.

The calculation of compression reinforcement for endurance is not conducted.

3.4.6.4.4 In the members of reinforced and steel concrete structures when calculated for endurance of sloping sections, the main tensile stresses are carried by the concrete if their values do not exceed R_{bt}, the resultant of the main tensile stresses is to be fully transmitted to the transverse bar and plate reinforcement. The stresses in the reinforcement therewith are not to exceed the design values of R_{sw}, and R_{swi} respectively.

3.4.6.5 Calculation of strength of sheet steel-to-concrete joint in steel concrete structures.

3.4.6.5.1 The structure of a sheet steel-to-concrete joint across their contact surfaces is to be calculated for longitudinal shear forces arising in the member during bending in the plane of bending for longitudinal shear forces due to temperature effects concrete shrinkage etc, for the forces in the transverse direction in the plane of bending during local forcing through the concrete under an external loading, etc.

3.4.6.5.2 The strength of connection or linkage of plate reinforcement with concrete is ensured if the following condition is observed:

$$T \leqslant m T_{sup} n \qquad (3.4.6.5.2)$$

where T = total shear force acting in the contact surface within the steel concrete member part under consideration;
m = coefficient of rest nonuniformity operation with $m = 0{,}9$ — for jointly operating rests of a different design. $m = 1{,}0$ — for rests of the same design;
T_{sup} = shear force carried by one rest and determined according to 3.4.6.5.7 and 3.4.6.5.8;
n = number of rests within the member part under consideration.

3.4.6.5.3 The longitudinal shear force in bending of the steel concrete member acting on the rests and anchors in the contact of plate reinforcement with concrete at the layout spacing 'u' is determined by the formulae:

$$T = Q S_t u / J_t \qquad (3.4.6.5.3\text{-}1)$$

or

$$T = N_{p(i-1)} - N_{p(i)} \qquad (3.4.6.5.3\text{-}2)$$

where Q = shearing force acting at the member part under consideration between rests;
S_t = transformed static moment of the steel plate cross-section about the neutral axis of the design member section;
J_t = transformed moment of inertia of the steel plate cross-section;
$N_{p(i-1)}$ and $N_{p(i)}$ = longitudinal tensile forces in plate reinforcement in cross-sections at the boundaries of the part under consideration.

3.4.6.5.4 In design of longitudinal anchorage with respect to a transverse force it should be ensured the rigidity and strength of a steel-to-concrete joint at support and end parts of a flexural member for which purpose the structures of a rigid rest type (see 3.4.5.12) are to be fitted in support sections. In continuous structures with transverse diaphragms in the planes of intermediate supports provision made for their strengthening with brackets is sufficient. At end parts of members the rigid rests are recommended to arrange outside support sides where practicable. The structural design of support structures of end parts is to provide for not only strength and rigidity of transverse diaphragms, but also to involve exterior steel plates of reinforcing in the operation in the support section.

3.4.6.5.5 The calculation of steel-to-concrete joint structures at the support parts of a member is to be performed for a total design longitudinal force in a plate steel in the plane of bending transmitted to the concrete, which is determined by the formula

$$N_p = R_{si} F_{si} \quad (3.4.6.5.5)$$

where R_{si} = design strength of a plate steel material;
F_{si} = design area of a plate steel cross-section.

In addition, the structure of a steel-to-concrete integration on the support is checked for shear forces determined by the Formula (3.4.6.5.3-1).

3.4.6.5.6 The calculation of steel-to-concrete joint structures is to be performed:

.1 with rigid rests — assuming the rectangular diagram of compression stresses transmitted to the concrete by the compression design surface of the rest;

.2 with flexible rests — reasoning from the conditions of concrete bearing under the rest with the rest operation in bending, according to 3.4.6.5.8;

.3 with sloping anchors — reasoning from the conditions of an anchor operation in the combination of tension and bending with concrete bearing.

3.4.6.5.7 The calculation of the structure of a joint on rigid rests is to be performed by the formulae:

for strength —

$$T_{sup} \leqslant 1{,}6 R_b F_{b,sm}, \quad (3.4.6.5.7\text{-}1)$$

for endurance —

$$T_e \leqslant 1{,}5 \gamma_{b1} R_b F_{b,sm}, \quad (3.4.6.5.7\text{-}2)$$

where T_{sup}, T_e = shear forces carried by one rest in calculation for strength and endurance, respectively;
$F_{b,sm}$ = design area of a rest or anchor placed normally to a shear force.

3.4.6.5.8 The calculations of strength for the structures of plate steel-to-concrete joints on flexible rests and bar anchors are to be performed by the formulae:

for flexible rests in the form of rolled channels, I beams, angles (without stiffening ribs like brackets) —

$$T_{sup} \leqslant 0{,}55(t_{fr} + 0{,}5 t_w) b_{dz} \sqrt{10 R_b}, \text{ кН}; \quad (3.4.6.5.8\text{-}1)$$

for flexible rests like round bars welded to plate reinforcement by its face end, at $2{,}5 \leqslant l/d \leqslant 4{,}2$ —

$$T_{sup} \leqslant 0{,}24 l d \sqrt{10 R_b}, \text{ кН}; \quad (3.4.6.5.8\text{-}2)$$

for similar flexible rests in the form of round bars at $l/d > 4{,}2$ —

$$T_{sup} \leqslant d^2 \sqrt{10 R_b}, \text{ кН}; \quad (3.4.6.5.8\text{-}3)$$

for flexible rests in the form of round bars the following condition is additionally to be fulfilled:

$$T_1 \leqslant 0{,}063 d^2 m R_m, \text{ кН} \quad (3.4.6.5.8\text{-}4)$$

where t_{fr} = sum of the radius of curvature and of the largest thickness of a rolling section flange, cm;
t_w = thickness of a rolling section web, cm;
l = length of the round bar of a flexible rest, cm;
d = diameter of the flexible rest or anchor bar, cm;
b_{dz} = width of the area of concrete bearing by a rest, cm;
R_b = design compressive strength of concrete for the 1st group limit states;
R_y = design strength of a steel structure material;
m = coefficient of operational conditions of a steel structure.

3.4.7 Calculation of reinforced and steel concrete structure members for cracking, crack opening and deformations.

3.4.7.1 The calculations of structure members for cracking and crack opening in concrete are to be performed:

in design of crack-resistant structures;

in design of structures with limited crack opening;

in identification of cracking zones to account for the reduction of rigidity characteristics of members in the calculations of redundant bar and massive structures.

The condition of cracking corresponds to an equality sign, and the condition of cracking resistance (prevention of cracks), to an inequality sign in the design formulae that correspond to the structure of the condition preventing the limit state 2.4.1.1 and 3.4.3.2:

.1 for centrally tensioned members, by the formula

$$\Phi = N, \ R = 1{,}5 R_{bt2} F_t \quad (3.4.7.1.1)$$

where F_t = transformed area of a member cross-section;

.2 for flexural members, by the formula

$$\Phi = M, \ R = 1{,}75 R_{bt2} W_t \quad (3.4.7.1.2)$$

where W_t = transformed modulus of section in bending for a tension side;

.3 for eccentrically compressed members

$$\Phi = M/W_t - N/F_t, \ R = 1{,}75 R_{bt2}; \quad (3.4.7.1.3)$$

.4 for eccentrically tensioned members

$$\Phi = M/W_t + N/F_t, \ R = 1{,}2 R_{bt2} \quad (3.4.7.1.4)$$

3.4.7.2 The calculation for the formation of cracks inclined to the longitudinal axis of a member is to be performed by the formula

$$\Phi = \sigma_{mt}, \ R = 1{,}5 R_{bt2} \quad (3.4.7.2)$$

where σ_{mt} = main tensile stresses in concrete determined according to the provisions of 3.4.6.1.5.

3.4.7.3 The calculations for cracking under repeated loadings are to be performed reasoning from the condition

$$\Phi = \sigma_{bt}, \ R = \gamma_{b1} R_{bt2} \quad (3.4.7.3)$$

where σ_{bt} = maximum normal and main tensile stresses in concrete;
γ_{b1} = coefficient of operational conditions of concrete under repeated loadings.

3.4.7.4 In calculations for concrete cracking the presence of reinforcement in the compressive zone of a section may be ignored.

3.4.7.5 In crack-nonresistant members of reinforced and steel concrete structures the calculation for opening of cracks which are normal to the longitudinal axis of a member is to be performed subject to the condition

$$\Phi = a_c,\ R = [a_c] \qquad (3.4.7.5)$$

where a_c = design width of crack opening, mm;
$[a_c]$ = permissible width of crack opening, mm, (see 3.4.7.8).

3.4.7.6 The width of crack opening a_T, (in mm) in members of reinforced and steel concrete structures is to be determined by the formula

$$a_c = 7C_D\varphi\varepsilon_s(4-100\mu)d^{0,5} \qquad (3.4.7.6)$$

where C_D = coefficient assumed equal to:
1,0 — with regard to a temporary loading;
1,0 — at $F_l/F_c < 2/3$,
1,3 — at $F_l/F_c \geqslant 2/3$;
F_l and F_c = maximum generalized forces (bending moment, longitudinal force, etc.) due to a full loading (permanent, operational effects and environmental loadings) and only to permanent and long duration loadings, respectively; with regard to a repeated loading $C_D = 2-\rho_s$;
ρ_s = coefficient of cycle asymmetry;
φ = coefficient dependent on the reinforcement type and assumed equal to:
1,0 — for deformed bar reinforcement,
1,2 — for deformed wire reinforcement,
1,4 — for plain bar and plate reinforcement;
ε_s = deformations in tensile reinforcement computed as σ_s/E_s without regard to the operation of the concrete tensioned in a section.
μ = coefficient of sectile reinforcing, $\mu = F_s/bh_0$, but not more than 0,02;
d = reinforcement diameter, mm.

Notes: 1. In calculation of members with exterior plate reinforcement instead of d in the Formula (3.4.7.6) $d_r = 1,5(F_{si}/\pi)^{0,5}$ is to be used, where F_{si} = area of plate tensile reinforcement in mm^2, at the section part 0,1 m wide.
2. In calculation of eccentrically and centrally tensioned members the calculation result by the Formula (3.4.7.6) is to be increased by 20 per cent.

3.4.7.7 The width of opening for the cracks inclined to the longitudinal axis of a member in way of the action of the maximum shearing forces is to be regulated by the restriction of the level of the maximum shear stresses in concrete, namely, the condition

$$\tau_{max} \leqslant 1,86R_{bt2} \qquad (3.4.7.7)$$

is to be met. In doing so, τ_{max} is to be determined in accordance with 3.4.6.1.5.

3.4.7.8 The permissible width of crack opening $[a_T]$ is to be taken reasoning from the operational conditions of a structure, data on environmental corrosive effects, intactness of bar and plate reinforcement, the impact of freezing and thawing processes, and not more than the values specified in Table 3.4.7.8.

Table 3.4.7.8

FOP hull area	Permissible width of crack opening $[a_T]$, mm		
	Reinforced concrete structures		Steel concrete structures
	seaside	inner side	
Bottom and sides in underwater part	0,10	0,15	0,25
Ice strake zone	0	0,10	0,25
Sides above water level	0,15	0,20	0,25
Decks and internal walls	0,20	0,20	0,25

3.5 TENSION LEG PLATFORMS

3.5.1 General.

3.5.1.1 Tension leg platform (TLP) consists of the following three basic components (structural elements):

hull;

tension legs;

ground foundation (anchor).

Designing TLP structural elements is to be carried out keeping due note of the acceptable requirements of Sections 1 and 2, considering additional instructions and regulations contained in the present Chapter.

3.5.1.2 The structural strength of TLP is to be tested on the basis of criteria mentioned under 3.5.3 for the following design conditions:

extreme load;

operation;

transit;

positioning;

removal from the drilling location;

replacement of tension legs, if provided for during operation period.

Replacement of tension legs means that one (or more) tension leg may be removed for survey, maintenance or replacement. This mode is to be determined considering anticipated frequency of the leg removal and duration of out-of-service period.

3.5.1.3 The TLP clearance h_c, in m, is to be not less than the largest of the values determined by the formulae:

$$h_c = \Delta_{100} + 1,2(D/\lambda_{100})^{1/4}h_{100} + 1,5;$$
$$h_c = \Delta_{100} + 4h_{r_{100}} + 0,5 \qquad (3.5.1.3)$$

where Δ_{100} = peak amplitude of a sea level change, which is probable once in 100 years, including storm surge, m;
h_{100}, λ_{100} = wave height and length, respectively, which are probable once in 100 years, m;
$h_{r_{100}}$ = thickness of rafted ice, which is probable once in 100 years, m;
D = diameter or the cross dimension of a conic leg at the waterline level, m.

3.5.1.4 In addition to the requirements of 1.3 the following TLP structures are to be subjected to technical supervision during manufacture and positioning:

tension legs;

ground foundation.

All the requirements set out in the above paragraph are applicable to the mentioned structures.

3.5.1.5 If the design technical requirements specify that the tension legs are to be subjected to replacement during operation period, i.e. their life cycle is shorter than that of a TLP, the wear margin for tension legs is to be determined basing upon the actual life cycle.

3.5.1.6 Requirements for the materials of TLP steel structures are set out in 3.5.5. Requirements for the materials of reinforced concrete or composite structures of ground foundation and TLP hull ice belt are to correspond to 1.5.2.

3.5.1.7 The requirements of this Chapter to the tension legs are drawn up mainly for the legs consisting of steel tubular elements. For design of tension legs consisting of ropes or chain cables one is to consider the requirements of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of MODU/FOP Rules as well as the requirements of the present Part, as far as applicable.

3.5.2 Loads.

3.5.2.1 When determining wind, current, ice, seismic, deck and mooring loads for a TLP and its elements one is to consider the requirements of 2.2, 2.3.6 to 2.3.10, 2.3.12, 2.3.13 and 3.3.2. When drawing up load combinations it is recommended to take into account the requirements of 2.3.11. Additional requirements to be considered in determining loads are set out in 3.5.2.2 to 3.5.2.6.

3.5.2.2 Alternating wind loads.

The relation between maximum w_{max} and average $\bar{w}$ velocities is determined by the gustiness coefficient G similarly to 2.2.2.3.

Keeping in mind that the profile of the TLP above water hull consists of extended elements, the pulse component of wind loads Q_w is to be determined considering coefficient of wind pulse correlation. General coefficient of correlation η is to be accepted equal to 0,8.

3.5.2.3 Wave loads.

Wave loads are of great importance for TLP both by their intensity and frequency, since natural periods of the system "tension legs — hull" are often found within the range of power bearing waves.

Taking into account irregular nature of wave conditions, the methodology for determining wave loads is to be based upon statistical approaches.

3.5.2.3.1 For assessing statistical characteristics of wave loads one of the two approaches is recommended. According to the first approach, the life cycle is presented as the set of wave stationary modes. Leg reactions characterized by the wave height of a given probability, average wave period, course angle and recurrence are being found for each mode, whereupon all the reactions are summarized.

Another approach is based on the concept of the severest conditions, at which the extreme value of reaction is the most probable for realization (see 2.2.3.5, 3.1.4.10, 3.1.4.11, 3.1.4.12).

3.5.2.3.2 As the basis dependence for determining wave loads one may use the Moritz equation considering diffraction corrections (see 2.3.9.1 and 2.3.9.2).

In obtaining probabilistic characteristics of wave loads on the basis on the Moritz equation one is to use the Weibull distribution, the parameters of which (scale and form) are to be determined from the diagrams and dependences on Fig. 3.1.4.9 (see 3.1.4.9). On X-axis on the diagrams one is to single out the relation of standard deviations of the wave load inertia and speed components.

3.5.2.3.3 The method based on the Moritz equation suggests that the structure does not cause distortion of speed and acceleration field of the liquid particles motion in a wave, thus preventing from fully considering the diffraction effects and hydrodynamic interaction of the structure elements. Though, this method makes it possible to fully use different wave theories, consider viscosity effects, extremities of the wave amplitude and the structure vibrations, shallow water effects.

It is reasonable to use the method in case the dimensions of a structure or its elements are so small that viscosity forces prevail in wave loads.

For large structural diameters ($D/\lambda > 0,2$) and relatively small wave heights it is advisable to use diffraction theory of calculation. The Moritz equation is preferably used for smaller diameters ($D/\lambda < 0,2$).

Method of linear diffraction theory is based on the assumption of smallness of a wave height and the platform vibration amplitude, potential character of liquid motion preventing from fully considering the viscous effects. Though, this method helps to consider the diffraction effects originated from flow past large bodies and connected with distortion of speed field in the wave.

The method is applicable in calculation of loads for the structures with dimensions equally large longitudinally and horizontally, multi-column platforms, when the diffraction effects are sufficient and viscosity forces are negligible.

3.5.2.3.4 Requirements of 3.5.2.3.1 to 3.5.2.3.3 also consider application of other approaches, approved by the Register upon appropriate review. In particular, the method of calculation of wave loads on TLP with the aid of ANCORED STRUCTURES software package approved by the Register may be used.

3.5.2.3.5 Disturbance forces of wave loads affecting TLP are permitted to be accepted equal to those of the semi-submersible units of a relevant structural and architectural type, while for local loads on TLP the wave loads are to be considered according to 3.2.3.4.

3.5.2.4 High frequency wave loads.

During a TLP operation the low frequency wave load may be subjected to superposition of high frequency loads generally of a pulse or impact nature (i.e. during realization of "springing" and "ringing" phenomena), respectively, vertical high frequency vibration of a TLP caused by pulse loads, and vertical high frequency vibration of a TLP caused by cyclic load from the vertical vibrations, rolling or pitching of a TLP with resonant or near-resonant periods. Because of perceptible presence of a high frequency component, in a number of cases the issue is considered in the context of its impact on fatigue life.

3.5.2.5 Vortical loads.

Vortical forces due to the current effecting the hull structures and tension legs are determined in accordance with the following.

3.5.2.5.1 Vortical vibration of a TLP blunt elements, caused by the current, may lead to undesired consequences at a certain current velocity. At this, frequency of vortex separation, determined by the following formula, is of great importance:

$$f = S_h \frac{\upsilon_T \sin\varphi}{D}, \text{ Hz} \qquad (3.5.2.5.1)$$

where S_h = Strouhal number;
υ_T = current velocity, m/s;
D = typical cross sectional dimensions of a structure (diameter), m;
φ = angle between axis of the structure and direction of the current.

The frequency (3.5.2.5.1) corresponds to the alteration of vortical forces across the current; the frequency of forces alteration along the current is half as low as that determined by (3.5.2.5.1).

3.5.2.5.2 Generally, the value of S_h corresponding to the frequency of vortex separation is determined in relation to Reynolds number R_n. On the basis of numerous field researches for determining the disturbing forces effecting the blunt structures, the following dependences may be used:

$S_h = 0{,}20$ for $R_n \leqslant 2{,}5 \times 10^5$.

$S_h = 0{,}27$ for $R_n > 2{,}5 \times 10^5$.

3.5.2.5.3 Coincidence of frequencies of unsteady forces with natural frequencies of the structure causes resonant phenomena with the possible considerable oscillation amplitude. Generally, vortical vibration is of hydroelastic nature and is to be studied by appropriate methods. The main peculiarity of natural vibrations is represented by velocity-expanded zones of resonant vibrations resulted from synchronization of natural vortex separation.

3.5.2.5.4 In the extended structures, such as tension legs, the resonant vibrations may emerge at all the operational velocities of the current. As a rule, transverse vibrations effecting extended tension legs are more intense than those directed along the current.

3.5.2.6 Dynamic aspects of a TLP behavior.

3.5.2.6.1 Dynamic characteristics of TLP are very important when assessing wind, wave, ice, seismic loads as well as load from current.

3.5.2.6.2 Frequency of the platform natural vibrations at *i*-th degree of freedom is determined by the formula:

$$p_i = \sqrt{K_i / M_i} \qquad (3.5.2.6.2)$$

where K_i and M_i = respectively, stiffness of a TLP system, including tension legs, and mass of a TLP with added mass (or moment of inertia of masses with respect to the drilling location).

3.5.2.6.3 Stiffness of the vertical leg system during horizontal shift for small rotation angles, kN/m, is determined by the formula

$$K_x = \frac{n_{t.l.} T_{t.l.}}{L_{Rt.l.}} + \frac{n_r T_r}{L_{Rr}} + n_{t.l.}\left(W_{t.l.} - \gamma \frac{\pi D_{t.l.}^2}{4}\right)\frac{L_{At.l.}}{2L_{Rt.l.}} +$$

$$+ n_r\left(W_r - \gamma \frac{\pi D_r^2}{4}\right)\frac{L_{Ar}}{2L_{Rr}} \qquad (3.5.2.6.3)$$

where $n_{t.l.}$ = number of tension legs;
n_r = number of raisers;
$T_{t.l.}$ = pretension of a tension leg, kN;
T_r = tension of a raiser;
$W_{t.l.}$ = weight of a tension leg per length unit in the air, kN/m;
W_r = weight of a raiser per length unit, including the liquid contained therein, in the air, kN/m;
$D_{t.l.}$, D_r = diameter of a tension leg and raiser, respectively;
$L_{At.l.}$, L_{Ar} = effective axial length of a tension leg and raiser, respectively, m;
$L_{Rt.l.}$, $L_{Rr.}$ = rotation radius of a tension leg;
γ = specific weight of water.

3.5.2.6.4 Non-linearity of the system in the horizontal direction is to be considered in the following ratio:

for the vertical leg system

$$u / L_{Rt.l.} \geqslant 0{,}02; \qquad (3.5.2.6.4\text{-}1)$$

for the inclined leg system

$$u / L_{Rt.l.\beta} \cos\beta \geqslant 0{,}1. \qquad (3.5.2.6.4\text{-}2)$$

3.5.2.6.5 Stiffness of the vertical leg system during vertical vibrations, kN/m, is determined by the formula

$$K_z = n_{t.l.} K_l + \rho g S \qquad (3.5.2.6.5)$$

where S = total area of floatation waterline, m^2;

ρ = mass water density, kN·c^2/m^4;
G = acceleration of gravity, m/c^2

3.5.2.6.6 Stiffness of the inclined leg system during vertical vibrations, kN/m, is determined by the formula

$$K_z = n_{t.l.} K_l \sin\beta + \rho g S. \qquad (3.5.2.6.6)$$

3.5.2.6.7 Stiffness of the system during rotational vibrations, kN/m, is determined by the formula

$$K_{xz} = 4K_l a^2 - \lambda_B \qquad (3.5.2.6.7)$$

where $\lambda_e = G\overline{KG} - F_B\overline{KB}$;
G and F_b = mass of the structures and buoyancy integral;
$\overline{KG}$ and $\overline{KB}$ = respectively, distance between the center of gravity and center of buoyancy from the level of hawses, m;
a = half of the distance between the hawses connecting tension legs, m.

3.5.2.6.8 Added masses and their moments of inertia for the i-th degree of freedom depend on the wave frequency and are determined on the basis of the certain theoretical solutions for the simple-shaped bodies and model tests for the irregular shaped bodies.

3.5.3 Strength criteria.

3.5.3.1 General

3.5.3.1.1 Generally, the main requirements set out in 2.4.1 are applicable for the TLP. Additionally to the dangerous states listed in 2.4.1.2 the following is to be included: slackening of a tension leg. Respectively, the criterion of leg tension maintenance is to be observed.

3.5.3.1.2 The tensile leg angle in the upper and lower coupling is to be chosen such that the leg remains undamaged in the area of its interaction with the hull and anchor structural elements considering characteristics of the flexible elements.

3.5.3.1.3 Buckling strength criterion for the TLP hull and foundation structural elements is to be in compliance with 2.4.3.

3.5.3.2 Ultimate strength criterion.

3.5.3.2.1 The ultimate strength criterion for extreme loading of the hull and anchor is determined by the expressions (2.4.2.2) considering the expressions (2.4.2.3.1) and (2.4.2.3.2). At that, safety factor η_1 is to be determined according to 3.5.3.2.4.

3.5.3.2.2 The ultimate strength criterion during extreme loading of tension legs is determined by the following expressions:

$$T_\Sigma < \eta_1 A \sigma_t, \; T_\Sigma \leqslant \eta_1 T_b \qquad (3.5.3.2.2)$$

where T_Σ = total design tension of a leg, caused by all the possible static and alternating loads (tension components are characterized in 3.5.4), kN;
A = design cross-section area of the leg, m^2;
s_t = temporary resistance of the leg material, MPa;
T_b = breaking stress of the leg, kN.

3.5.3.2.3 The ultimate strength criterion for the operating and transit conditions, the conditions of installation in and removal from a drilling position and safety factors, respectively, are to be in accordance with 2.4.2.4, 2.4.2.5 and 3.3.1.1.

3.5.3.2.4 Safety factors η_1 for the criteria set out in 3.2.3.2.1 and 3.5.3.2.2 are not to exceed the values given in Table 3.5.3.2.4.

3.5.3.2.5 Ultimate strength criterion for a tension leg replacement practice is subject to special consideration by the the Register if the leg replacement in wave conditions is permitted. Otherwise one is to be guided by the above criteria considering the fact that only static loads are effective.

3.5.3.2.6 Additional ultimate strength criteria for the ice belt structures of the ice-resistant TLP are to be in compliance with 3.3.3.

3.5.3.3 Fatigue strength criterion.

3.5.3.3.1 Fatigue strength criterion is to be applied for the structural elements, for which the strength may represent the ultimate form of destruction, for example, tension legs — foundation — hull structure joints, as well as tension leg elements. The list of joints is to be agreed by the designer with the Register.

3.5.3.3.2 Designing of the platform structures is to be performed on the basis of the "safe damage"

Table 3.5.3.2.4

Name of a structure	Strength criterion	Structural elements		
		Special	Primary	Secondary
Hull and foundation beyond the area of interaction with tension legs	p. 3.5.3.2.1, criterion 2.4.2.3.1	0,75	0,80	0,83
	p. 3.5.3.2.1criterion 2.4.2.3.2	1,25	1,35	1,45
Hull and foundation in the area of interaction with tension legs	p. 3.5.3.2.1 criterion 2.4.2.3.1	0,65	0,70	–
	p. 3.5.3.2.1 criterion 2.4.2.3.2	1,20	1,30	–
Tension legs	3.5.3.2.2	0,55	0,60	—

criterion, according to which the fatigue criterion realization is oriented at the stage of fatigue macrocrack initiation rather than the crack development. Characteristics of ultimate relative vulnerability are determined in 2.4.4.

3.5.3.3.3 The sources of cyclical loads are waves, wind, current, ice and seismicity reason. The initial data for each type of cyclical loads is recurrence of environmental conditions.

3.5.3.3.4 In the absence of sufficient statistics on the structure loading the fatigue life at wave, seismic or alternating ice loads is recommended to be determined on the basis of the analytical dependencies.

3.5.3.3.5 Influence of high frequency components of a wave load from "springing" and "ringing" (see 3.5.2.4) on the tension leg fatigue life is determined by a reduction coefficient γ dependent on relation of standard deviations of high frequency and low frequency components, as well as on **m** parameter.

3.5.3.4 Criterion of tension maintenance in the leg.

3.5.3.4.1 The tension maintenance criterion stipulates the requirements aimed at preventing the origination of a tension leg slackening, as the result of which the tension leg is considered to be out of service.

3.5.3.4.2 this criterion may be defined in the following way:

$$T_{\Sigma э} \leqslant \eta_1 {}^* T_o \quad (3.5.3.4.2)$$

where $T_{\Sigma э}$ = design leg tension dependent on design loads leading to tension minimizing by elimination of the original (initial) tension on still water;
T_o = original (initial) tension on still water;
$\eta_1{}^*$ = safety factor; $\eta_1{}^*$ = 0,70.

3.5.4 Peculiarities of strength calculation and TLP design.

3.5.4.1 General.

3.5.4.1.1 Generally, the main requirements set out in 2.5.1 and 2.5.2 are applicable for the TLP design. In addition it is to be noted that the TLP vital reactions are represented by linear and angular motion of the hull, as well as internal axial forces in the TLP.

3.5.4.1.2 Damage of one leg is not to lead to progressive breaking of other legs or excessive damaging of the hull or foundation in the areas of interaction with tension legs. The Register may require the calculation confirming that being exposed to the environmental loads maximum for the given operational area for a one-year period the structural strength of the platform with a damaged tension leg will be maintained.

3.5.4.1.3 In designing of TLP one is to consider that the hull shift with regard to the ground foundation would not cause damage of the structure and, finally, emergency situations.

3.5.4.2 Hull.

3.5.4.2.1 A particular method of the TLP hull design is to be determined according to the peculiarities of the structure. When calculating hull strength for the multi-column TLP the regulations of 3.2 related to the semi-submersible units may be applied. When calculating hull strength for the tower-shaped TLP the regulations of 3.3 related to monopods (monocones) may be applied.

3.5.4.2.2 Calculation of girder system, separate girders, plates, calculation of structural elements' buckling strength is to be carried out in accordance with 2.5.3 to 2.5.5.

3.5.4.2.3 Ice belt structures of ice-resistant TLP are to be calculated in accordance with 3.3.4. At that one is to consider that ice formation is not to touch with the areas of the hull and tension legs joint.

3.5.4.2.4 Calculation of steel concrete ice belt is to be carried out in accordance with 3.4.

3.5.4.3 Tension legs.

3.5.4.3.1 A tension leg consists of the three basic elements:

area of interaction with the hull;

area of interaction with the foundation;

basic part of the leg – joints between all the above elements.

The area of interaction with the hull is designed for the following functions:

control and regulation of the required tension, joining tension legs with the hull, perception of transverse forces and bending moments. The area of interaction with the foundation is designed for the following functions:

maintenance of structural joints between the foundation and a leg, perception of transverse forces and bending moments.

The operational peculiarities of each area determine the deflected mode character and appropriate approaches to the structural strength calculation.

3.5.4.3.2 Tension in any tension leg is the sum of a range of components possessing different physical values, i.e.:

$$T_\Sigma = \sum_{i=1}^{n} T_i \quad (3.5.4.3.2)$$

where n = number of considered components.

These components are subdivided into two radically different groups:

deterministic (including static) and occasional.

3.5.4.3.2.1 The full formulation of tension components is as follows:

deterministic (or quasideterministic) components:

T_o = original tension at the mean water depth;

T_t = tension from storm surge;

T_λ = leg tension dependent on alteration of ballast, cargo etc. weight;

T_m = tension caused by capsizing moment from wind load and current;

T_s (wave or ice) = tension caused by sagging due to static loads and slowly changing shift (wave drift or constant component of ice load, wind, current);

T_f (wave or ice) = tension caused by foundation shift under the influence of water or ice;

occasional components:

T_w (or T_{ice}) = alternating tension component from wave or ice forces with regard to average shift (includes tension from horizontal forces, vertical forces, vibrations (rolling and pitching), generally form rotation forces);

T_i = tension caused by vertical oscillation, rolling or pitching at the natural oscillation frequency of the platform (ringing and springing, including possible underdeck slamming loads).

3.5.4.3.2.2 Standard deviation of total tension is determined by the formula:

$$\sigma^2_{T_\Sigma} = \sum_i \sigma^2_{T_i} + 2\sum_i\sum_j \rho_{ij}\sigma_{T_i}\sigma_{T_j} \quad (3.5.4.3.2.2)$$

where σ_{T_i}, σ_{T_j} = standard deviations of separate components determined basing upon the idea of statistical dynamics;

ρ_{ij} = coefficient of correlation between separate tension components.

3.5.4.3.2.3 As the wave tension distribution law the Weibull distribution with the parameters of scale a and K form (see 3.1.4.8 and 3.1.4.9) is recommended.

3.5.4.3.2.4 As the ice tension distribution law the Weibul distribution with the parameters of scale $\bar{b}$ and K form, determined depending on relation a_h/D, where a_h is the parameter of ice thickness distribution scale, D is the obstacle diameter at the waterline level, (see 3.3.2.3.3 and 3.3.2.3.5) is recommended.

3.5.4.3.3 Basic stages of tension leg design procedure including consideration of ultimate and fatigue strength as well as the hull and foundation impact on legs, are as follows:

platform dimensions – determining the TLP general configuration;

leg predesign – assessment of pretension and other input data necessary to determine the TLP dimensions;

analysis of reactions – determining the structure's shift and minimum/maximum leg tension;

horizontal leg reactions – determining bending moments in legs and horizontal vibrations;

minimum tension – determining the minimum leg tension;

pretension analysis – check of the preliminary maximum stresses and fatigue life;

check of service limitations – check of admissible shifts of the structure as well as check of vibrations and leg shifts;

fatigue life – determining fatigue strength under effect of axial and bending forces combination;

final check – check of maximum stresses, minimum tension, fatigue life etc.;

mutual analysis – determining necessity of carrying out the mutual reactions analysis;

model tests (not obligatory) – confirmation of vibrations and loads on the leg.

3.5.4.4 Ground foundation.

3.5.4.4.1 Primarily ground foundation is aimed at tension leg mooring, TLP loads perception and transmission fully or partially to the seabed foundation soil.

The main requirement to the foundation systems is together with tension legs to reliably buoy the floating structure at the certain area of the open sea, restrict its shift within the specified area and, thus, provide normal operation conditions. Safety of the whole unit depends on operational reliability of the positioning system; breaking from the positioning point is inadmissible.

3.5.4.4.2 For the central tension legs buoyancy the foundation structures with ram piles as well as those of gravitational or mixed type may be used. The units may be made whether as a separate, supported by piles or masses or their combination, one-piece structure, to which all the tension legs and raisers are fixed, or as a system of separate, independent foundation structures for groups or strands of tension legs and borehole pipes.

Besides, the anchors consisting of one or several suction piles as well as the anchors of Stevmanta or SEPLA type may be considered as peripheral foundation systems.

3.5.4.4.3 The load may be transmitted to the ground in several ways, i.e. through the tension legs joined to the piles directly, through the surface ground-based foundation plates (templates) that transmit tension leg forces through the piles to the ground through surface gravity foundation.

3.5.4.4.4 Calculation of ground foundation is to include calculation of the foundation structure deformation and strength and calculation of the foundation buckling strength and shifts with regard to the ground.

In designing the TLP foundation structure the following issues regarding peculiarities of the structure's operating conditions are to be considered:

load eccentricities being the result of alteration of the tension leg forces within the group;

consequences of a tension leg/raiser installation - possible raise (pulling out) and re-location of the tension legs/raisers during service life of the platform;

position (installation) and operation (regulatory) design tolerances;

issues on survey and check of compliance of the foundations with the required operational capabilities.

3.5.4.4.5 Strength calculation for steel, reinforced concrete and steel concrete structures of ground foundations is to be carried out in accordance with acceptable requirements set out in 2.5 and 3.4.

3.5.4.4.6 Buckling strength calculation for seabed foundations is to meet the requirements stated in Section 4.

3.5.4.5 Joints.

3.5.4.5.1 The hull — tension legs joint.

3.5.4.5.1.1 The structures joining the hull and tension legs take up leg reaction by means of the two supporting areas:

upper area, taking up mainly tension force of legs;

lower area, taking up transverse reactions originated from the platform horizontal shift.

3.5.4.5.1.2 Supporting structures of the upper supporting area are to be designed for impact of a tensioner or maximum possible vertical leg reaction. At that, sufficient resistance of the structure considering statics and dynamics of the platform shift is to be checked:

to loss of buckling strength and necessary stiffness;

to collapse, shift or bending stresses.

Possibility of unequal distribution of the tension leg reaction distribution is to be considered.

3.5.4.5.1.3 Supporting structures of the lower supporting area should be designed for the impact of a flexible element and maximum possible horizontal reaction considering statics and dynamics of the platform shift.

Sufficient resistance of the above structures shall be checked:

to loss of buckling strength;

to collapse, shift or bending stresses, local peak contact stresses.

3.5.4.5.1.4 Sufficient stiffness of work contact surfaces is to be specified in order to maintain their operating capability during whole service life of the platform.

3.5.4.5.2 Anchor — tension legs joint.

3.5.4.5.2.1 Structures of anchor — tension legs joints are represented by the two supporting areas:

upper area with a flexible element taking up horizontal reactions originated from the platform shift;

lower area taking up vertical reactions originated from the platform shift.

3.5.4.5.2.2 Supporting structures of the anchor upper supporting area are to be designed for the impact of flexible element or maximum possible horizontal reaction considering static and dynamic impact on the platform and the leg. The following structural resistance is to be checked:

to loss of buckling strength;

to collapse, shift or bending stresses;

to local peak contact stresses;

ambient pressure for dry sea chests and closed spaces.

3.5.4.5.2.3 Supporting structures of the lower supporting area are to be designed primarily for the impact of maximum possible vertical leg tension considering statics and dynamics. The anchor structural resistance is to be checked by calculation of:

loss of buckling strength and necessary stiffness;

collapse, shift or bending stresses;

local peak contact stresses.

3.5.4.5.2.4 Structures of anchor — tension leg joints are to be provided with thickness margin considering high erosion and abrasion wear and probable chemical corrosion of steel.

3.5.4.5.2.5 When ropes are used as tension legs, the structures of the upper and lower areas may join together.

3.5.4.5.3 Joints of tension leg elements.

3.5.4.5.3.1 The main constructive way in designing joints equal to the tension leg in strength is the reduction of effective stresses through the extension of sectional area of the joint.

3.5.4.5.3.2 In design of the tension leg joints the strength calculation is to include:

total leg tension;

total leg bending in the area in question;

local bending induced by sectional eccentricity;

local concentration of stresses caused by peculiarities of the joint and/or weld.

3.5.4.5.3.3 In case the internal volume of the leg is isolated, the strength calculation is to additionally consider the impact of internal and environmental stresses on the joint stressed state.

3.5.4.5.3.4 For the structures of joints and tension leg elements check calculation of local impact strength against the reactions transmitted from the upper and lower supporting areas of the anchor and hull structures considering deformation of their flexible elements is to be carried out.

3.5.4.5.3.5 If strength check for the tension leg joints shows that their strength and service life shall not provide the platform real service life, the above calculations are to be re-performed considering replacement of tension legs during the platform operation.

3.5.4.6 Peculiarities of structural design in the seismically dangerous regions.

3.5.4.6.1 When designing TLP in the seismically dangerous regions anchor strength and bearing capacity, tension legs and hull strength considering large-scale seabed deformations, possible ground dilution, as well as "seaquake", i.e. underwater acoustic impact on TLP structures are to be ensured.

3.5.4.6.2 It is necessary to avoid anchor arrangement at the seabed areas where earthquakes may cause large scale ground deformation.

If, nevertheless, anchors were arranged in the areas of considerable seismic shifts, the anchor bearing capacity is to be checked taking into account the specified ground shifts (i.e. slide of subsea slopes).

3.5.4.6.3 When assessing anchor stiffness considering seismic loads both maintenance of structural strength and bearing capacity of the seabed subjected to dynamic loads are to be provided.

One is to take into account possible temporary decrease of anchor bearing capacity caused by dynamic dilution of the ground. At that, one is to define the extent of possible degradation of bearing capacity, as well as the period of bearing capacity recovery (based upon the time required for ground consolidation).

The time specified is to be considered when choosing design foundation ground characteristics with regard to various combinations of loads and stresses.

3.5.4.6.4 In calculation of the anchor stressed state and buckling strength one is to take into account the anchor mass as well as the additional masses of water and anchor legs.

3.5.4.6.5 Consequences of seismic load transmission from the waterarea bottom to the TLP hull through the tension legs is to be considered when seismic horizontal and vertical shifts of the waterarea bottom in the anchor legs location areas exceed relative permissible TLP shifts caused by wave loads at drilling. In such cases the tension leg forces are to be determined basing upon the values of anticipated seismic shifts of anchor legs with regard to the water area bottom.

The values of the above forces are to be used for checking tension leg strength and calculating TLP strength including the elements joining tension legs to the TLP hull and bearing.

3.5.4.6.6 As the design underwater acoustic load on TLP hull and tension legs one is to regard the hydrodynamic pressure applied to the TLP bottom that is time-varying according to the harmonic law with period T^{de} amplitude value p^{de}_{amp} determined by the formula

$$p^{de}_{amp} = kT^{de}\exp(0,72J^{de}) , \qquad (3.5.4.6.6)$$

where $k = 0,003$, MPa·s^{-1}.

In the absence of sufficient seismic information it is permitted to accept T^{de} value equal to 0,50 s.

3.5.5 Requirements to materials.

3.5.5.1 General.

3.5.5.1.1 Materials used for manufacturing the TLP hull and anchor structures beyond the areas of tension leg joints shall be in conformity with 1.5.1 of the present Part and Part XII "Materials" of MODU/FOP Rules.

3.5.5.1.2 The present Section includes the specified requirements for the hull and anchor material in the areas of tension leg joints (mainly, special structural elements), as well as the requirements for the tension leg material that are to be regarded as addition to 1.5.1 of the present Part and Part XII "Materials" of MODU/FOP Rules.

3.5.5.1.3 For all the structures listed in 3.5.5.1.2 the resistance of hydrogen brittleness materials is to be assessed.

3.5.5.2 Hull.

3.5.5.2.1 Set of mechanical properties of materials of the hull structures interacting with a tension leg, tensioner or flexible element is to be assessed additionally with regard to the following damage types caused by local contact stresses on the work surfaces of the structural elements:

plastic straining, collapse or pressing out;

erosional and abrasive wear of contact surfaces;

fatigue fracture of wear surface;

brittle fracture of wear surface and crumbling of material.

3.5.5.2.2 For the hull structures exposed to tension leg reactions it is required to use steel materials at least 70 mm thick with yield stress $\sigma_{0,2} \leqslant 550\sigma_t$ MPa.

3.5.5.2.3 Temporary resistance of the hull structural materials σ_t aimed to adequately provide strength and plasticity is to correspond to the relation $\sigma_{0,2} \leqslant 0,85\sigma_t$.

3.5.5.2.4 In order to adequately provide plasticity of special structures of the TLP hull the material is to have a residual relative contraction Z_z during elongation of the material in the direction perpendicular to the plate surface: $Z_z \geqslant 25$ %. Relative elongation A_5 during testing of samples is to be not less than $A_5 \geqslant 18$ %.

3.5.5.2.5 Contact work surfaces of the hull special structures are to be designed for collapse and be stiff enough to prevent abrasive wear.

3.5.5.2.6 Taking into account considerable dynamic components of loading the material of the hull special structures is to be in compliance with the additional requirements regarding the following crack-resistance requirements upon the Register approval:

impact toughness during testing temperature; impact energy:

when testing the specimens cut in the rolling direction KVL $\geqslant$ 57 J;

when testing the specimens cut across the rolling direction KVT $\geqslant$ 40 J;

CTOD value is to be equal to:

for basic metal CTOD ⩾ 0,25 mm;

for heat-affected zone CTOD ⩾ 0,20 mm;

the above temperatures are to be obtained at the temperatures equal to those of impact toughness testing.

the temperature value of zero fracture toughness for the structural materials is to be less than NDT = −30 °C.

3.5.5.3 Anchor.

3.5.5.3.1 Mechanical properties of the anchor structures interacting with tension legs are to be assessed with regard to the damage types listed in 3.5.5.2.1, as well as regarding:

additional abrasion wear induced by water-risen seabed soils;

high chemical corrosion;

stress corrosion cracking resistance.

3.5.5.3.2 For the special anchor structures it is recommended to use steel materials less than 120 mm in thickness and having a yield stress less than $\sigma_{0,2} \leqslant 550$ MPa with the continuity check at thicknesses above 70 mm.

3.5.5.3.3 Temporary resistance of material is to be in compliance with 3.5.5.2.3.

3.5.5.3.4 The material of the anchor special structures is to have a residual relative contraction during elongation of the material in the direction perpendicular to the plate thickness: $Z_z \geqslant 20$ %. Relative elongation A_5 checked during cutting out the through-plate-thickness samples from the center of the plate is to be not less than $A_5 \geqslant 18$ %.

3.5.5.3.5 Contact work surfaces of the anchor special structures are to be in compliance with 3.5.5.2.5.

3.5.5.3.6 Crack-resistance characteristics of the anchor special structures are to meet the requirements of 3.5.5.2.6 upon the Register approval. The testing samples are to be cut from the subsurface layer of material.

3.5.5.4 Tension leg.

3.5.5.4.1 Mechanical properties of the tension leg material are to be tested with regard to the types of possible fracture resistance corresponding to the leg functionality.

3.5.5.4.2 Requirements to the material of the area of interaction with the anchor are to be in accordance with 3.5.5.1 and 3.5.5.3.

3.5.5.4.3 Requirements to the material of the area of interaction with the hull are to be in accordance with 3.5.5.1 and 3.5.5.2.

3.5.5.4.4 Requirements to the material of the tension leg's middle section are to be in accordance with 3.5.5.1 and 3.5.5.2.

3.5.5.4.5 Circumferential yield stress $\sigma^0_{0,2}$ and ultimate strength σ^0_t of the leg is to be in accordance with the requirements:

$$\sigma^0_{0,2} \geqslant 0{,}9\sigma_{0,2}\ ;$$
$$\sigma^0_t \geqslant 0{,}9\sigma_t. \qquad (3.5.5.4.5)$$

3.5.5.4.6 For leg coupling impact energy is to be equal to:

for the specimens cut in the rolling direction KVL ⩾ 68 J;

for the specimens cut across the rolling direction KVT ⩾ 46 J;

CTOD value at the temperatures equal to the temperatures of impact toughness testing is to be equal to:

for basic metal CTOD ⩾ 0,25 mm;

for heat-affected zone CTOD ⩾ 0,18 mm (with welding);

The temperature value of zero fracture toughness is to be less than NDT ⩽ −40 °C with the wall thickness being less than 40 mm.

3.5.5.4.7 The requirements to the material set out in 3.5.5.4.1 to 3.5.5.4.6 may be subjected to revision or dispensation upon the Register approval, if the design provides for tension legs replacement during TLP service.

4 SELF-ELEVATING MODU/FOP STABILITY ON SEABED

4.1 GENERAL

4.1.1 The interaction of self-elevating MODU/FOP supporting structures with seabed has a significant impact on characteristics in terms of general stability of structures.

4.1.2 The way to keep a FOP on seabed depends on the overall dimensions of the structure, the actual loading level, soil properties, the external effects dynamics, the extent of environmental importance of the structure. For the way to keep on seabed FOP are divided into:

gravity;

pile-supported;

combined (combination of gravity and pile-supported) FOP.

4.1.3 The way to keep a self-elevating MODU on seabed is gravitational with pre-loading of legs into seabed.

4.2 STABILITY OF SELF-ELEVATING MODU ON SEABED

4.2.1 Stability against capsizing on seabed.

The safety factor against self-elevating MODU capsizing on seabed is to be not less than

$$K_o = M_r / M_c \geqslant 1,50 \qquad (4.2.1\text{-}1)$$

where M_r = righting moment due to self-elevating MODU weight forces, kN·m;
M_c = total capsizing moment due to extreme effect of external forces about the plane of self-elevating MODU's support on seabed, kN·m;

The worst combination of a righting and capsizing moments depending on the loading condition of a self-elevating MODU, the values and directions of external effects is to be considered.

With reasonably developed in area supporting surfaces of footings, the presence of a support moment is to be considered, i.e. the following condition is to be considered as criterion

$$M_r / (M_c - M_s) \geqslant 1,50 \qquad (4.2.1\text{-}2)$$

where M_s = support bending moment from the direction of seabed, kN·m.

4.2.2 Stability in shifting.

The safety factor against self-elevating MODU capsizing on seabed is to be not less than

$$K_s = Pf / T \geqslant 1,50 \qquad (4.2.2)$$

where P = gravity load of a self-elevating MODU per leg with regard to the displaced water;
T = design value of a total shear force in way of a foundation;
f = friction coefficient of a supporting surface against seabed.

The worst combination of a pontoon weight depending on the self-elevating MODU loading condition, and of a total shear force depending on the direction of extreme external effects is to be considered.

4.2.3 Stability in subsidence.

A safety factor for the subsidence of one of self-elevating MODU legs into seabed is to be not less than

$$N_3 / N > K_s \qquad (4.2.3)$$

where N_3 = pre-loading force;
N = design value of a total axial force;
K_s = 1,0 — for four-leg units;
K_s = 1,05 — for three-leg units.

The worst situation in terms of leg subsidence is to be considered as it is this condition that is most commonly critical. The subsidence condition establishes the necessary amount of ballast for three-leg units and impacts the volume and arrangement of spaces in a pontoon.

4.3 STABILITY OF FOP ON SEABED

4.3.1 Gravity FOP.

4.3.1.1 General.

The gravity FOP structure is to be designed so as to ensure the proper conditions for FOP installation in the specified drilling position and to exclude the following kinds of limit states:

loss of the carrying capacity of a FOP-base system;

FOP capsizing;

excessive FOP shifting (subsidence, horizontal shifts, turning angles);

excessive seabed pressure on a skirt and inner ribs resulting in violation of the conditions of skirt-FOP structure assembly strength.

In design of a FOP foundation it is also to be prevented:

limit state by the conditions of noncohesive soils liquefaction under dynamic effects;

significant seabed scour near legs.

The methods of the calculation of gravity FOP stability on seabed including design values of loadings, resistance and reliability indices are to be approved by the Register. The main criteria are given in 4.3.1.2 to 4.3.1.6.

4.3.1.2 Criterion by conditions of gravity FOP installation.

4.3.1.2.1 In installation of a FOP the opportunity of skirt and inner ribs pressing-in into base ground for their entire height is to be assured what ensures the proper conditions of the FOP joint operation with the base.

4.3.1.2.2 The criterion of installation conditions control is determined by the expression

$$N > KN_u \qquad (4.3.1.2.2)$$

where N = vertical force transmitted from a FOP to a base at the instant of its setting, kN;
N_u = force of soil resistance to skirt and inner ribs pressing-in determined depending on their perimeters, heights, thicknesses and the results of static probing of the upper layer of base soil within which the skirt and ribs are pressed in, kN;
K = normalized value of the assurance coefficient ensuring full pressing-in of the "skirt" structure into the soil.

The force N_u may be determined experimentally by pressing in the fragments of a ribbed structure into the base soil.

4.3.1.3 Criterion of carrying capacity of FOP-base system.

4.3.1.3.1 The criterion of a carrying capacity of the system regulates the requirements for the relation between a force effect F and resistance forces R. This criterion is to be met in all potential schemes of limit equilibrium attainment (for a plane and depth shear at the different potential outline of shear surfaces).

4.3.1.3.2 The criterion of a carrying capacity of a platform-base system is determined by the expression

$$R/F \geqslant k_{s,n} \tag{4.3.1.3.2}$$

where F = design value of a generalized force effect used for estimating a limit state;
R = design value of a generalized resistance force (carrying capacity) counteracting the force F;
$k_{s,n}$ = normalized value of the coefficient of a carrying capacity.

4.3.1.3.3 The carrying capacity of the system may also be estimated according to the results of deflected state calculations by the comparison of operational loadings acting on the system with the loadings bringing the system about a limit state with the formation of significant plastic zones in the base.

General stability of the structure on the seabed at dynamic loads is recommended to be assessed considering changes in the soil strength properties.

4.3.1.4 Criterion of limit eccentricity in application of loading resultant.

4.3.1.4.1 This criterion sets the requirements aimed at prevention of the potential hazardous state associated with the capsizing of gravity FOP with large eccentricities in application of loadings causing arising of tensile zones at the contact of a bearing block bottom with base earth.

4.3.1.4.2 The criterion of a limit eccentricity is determined by the expression

$$e \leqslant e_l k_{s,n} \tag{4.3.1.4.2}$$

where e = eccentricity of application of the resultant of all loadings (excepting a lateral earth pressure) acting on the FOP, m;
e_l = limiting value of a loadings resultant eccentricity set by the design specification; it is allowed to assume $e_l = B/6$ for the bottom of a rectangular foundation;
B = dimension of a bearing block in the direction of shearing load application.

4.3.1.5 Criterion of limit shifts.

4.3.1.5.1 The criterion of limit shifts sets the requirements aimed at prevention of the potential emergence of a hazardous state associated with the violation of the condition of a platform's normal operation.

4.3.1.5.2 The criterion of limit shifts is determined by the expression

$$S \leqslant S_u \tag{4.3.1.5.2}$$

where S = joint deformation of a base and structure (subsidence, horizontal shifts, heel, etc.);
S_u = limit values of the joint deformation of a base and FOP set by the design specification and equipment maintenance rules (in setting the value the potential disturbance of utility systems associated with the structure is to be taken into account).

4.3.1.6 Criterion of value of soil pressure on skirt and inner ribs.

4.3.1.6.1 This criterion sets the requirements aimed at prevention of the potential hazardous states associated with the break of strength of rib-structured members caused by the soil pressure.

The criterion is to be met for all the members of a ribbed structure and loading combinations.

4.3.1.6.2 The criterion of a limit soil pressure determined by the expression

$$P \leqslant P_l \tag{4.3.1.6.2}$$

where P = characteristic value of soil pressure diagram;
P_l = limiting value of P; the P_l value corresponds to maximum allowable stresses in the skirt, inner ribs and adjoining areas of the FOP.

4.3.2 Pile-supported FOP.

4.3.2.1 General.

4.3.2.1.1 The structure of a FOP pile foundation is to be designed to prevent the possibility of arising advent of the following kinds of a limit state:

loss of a carrying capacity of a FOP-base system;

deformation of the entire base or its separate elements causing the break of the normal operation of a structure.

In design of a FOP pile foundation it is also to be prevented arising of:

limit states as to strength and cracking (crack opening) for piles and piled mat foundation under a horizontal loading and bending moment;

limit state as to the conditions of noncohesive soils liquefaction under dynamic effects;

significant seabed scour near legs.

The methods of calculation of pile-supported FOP stability on seabed including design values of loadings, resistance and reliability indices are to be approved by the Register. The main criteria are given in 4.3.2.2 to 4.3.2.3.

4.3.2.2 Criterion of carrying capacity of pile base.

4.3.2.2.1 The criterion of a carrying capacity of a base soil for a single pile being part of a foundation and out of it takes the form

$$N \leqslant F_d/\gamma_k \tag{4.3.2.2.1}$$

where F_d = design carrying capacity of a single pile, kN;
γ_k = reliability index determined depending on the way of carrying capacity determination and on the number of piles in the foundation;
N = design loading transmitted on a pile (longitudinal force arising in it due to the design loadings acting on the foundation at their most adverse combination).

4.3.2.2.2 The design loading on a pile should be determined considering the foundation as a framed structure carrying vertical and horizontal loadings, and bending moments. The design loading on a pile for foundations with vertical piles may be determined by the formula

$$N = N_d/n \pm M_x y/\Sigma y_i^2 \pm M_y x/\Sigma x_i^2 \tag{4.3.2.2.2}$$

where N_d = design compression force, kN;
M_x, M_y = design bending moments, kNm, about the principal central axes x and y of the piles plan in the plane of a mat foundation bottom;
n = number of piles in the foundation;
x_i, y_i = distance from principal axes to each pile axis, m;
x, y = distance from principal axes to the axis of each pile for which the design loading is computed, m.

4.3.2.2.3 The design carrying capacity as to a pile foundation soil at large may be determined as the sum of carrying capacities of independent single piles where the distance between pile axes is over three pile diameters. In other cases, the mutual influence of piles is to be considered or the relevant substantiation of ignoring it is to be provided.

4.3.2.3 Criterion of limit deformations.

4.3.2.3.1 The criterion of limit deformations sets the requirements aimed at prevention of the potential hazardous state associated with the violation of normal operation conditions.

4.3.2.3.2 The criterion of limit deformations takes the form

$$s \leqslant s_u \qquad (4.3.2.3.2)$$

where s = joint deformation of a pile, m, pile foundation and structure (subsidence, displacement, a turning angle, the relative difference of subsidences of piles, pile foundations, etc.);
s_u = limiting value for joint deformation of the base of a pile, m, a pile foundation and structure set by the design and equipment maintenance rules.

4.3.2.3.3 In calculation of pile deformations due to horizontal loading and bending moment it is allowed to use appropriate calculation methods for other similar structures, approved by the Register. The methods in use are to reflect the nonlinear nature of a "loading — pile head displacement" relation.

4.3.2.3.4 The horizontal loading acting on a foundation with vertical piles of the same cross-section may be assumed as uniformly distributed among all piles.

APPENDIX 1

CHARACTERISTICS OF WIND AND WAVE CONDITIONS

Table 1

Extremes of wind velocity and wave height with recurrence period of 50 years

Sea	Average wind velocity (10 min averaging period) $\overline{W}_{50}$, m/s	Wave height with 3 per cent probability of exceedance h_{50}, m
Caspian Sea	45,0	13,0
Black Sea	43,0	12,5
Barents Sea	46,0	19,0
Okhotsk Sea	48,0	19,0

Table 2

Recurrence of wave heights and periods in the Caspian Sea, %

$\bar{\tau}$, c	$h_{3\%}$, m											
	0 — 1	1 — 2	2 — 3	3 — 4	4 — 5	5 — 6	6 — 7	7 — 8	8 — 9	9 —10	10 — 11	11 — 12
0 — 1	7,11											
1 — 2	14,58											
2 — 3	6,44	20,21										
3 — 4	0,62	9,11	5,24									
4 — 5	0,33	6,32	10,02	5,36								
5 — 6	0,08	3,17	1,12	0,70	0,68							
6 — 7	0,07	1,54	0,66	0,49	0,44	0,05						
7 — 8	0,05	1,38	0,40	0,29	0,37	0,06	0,04	0,03				
8 — 9	0,03	0,97	0,27	0,23	0,21	0,07	0,06	0,03	0,005			
9 —10	0,02	0,05	0,05	0,16	0,17	0,12	0,05	0,02	0,015	0,013	0,010	0,005
10 — 11	0,009	0,009	0,01	0,05	0,05	0,05	0,04	0,01	0,010	0,010	0,005	0,005
11 — 12	0,005	0,005	0,005	0,03	0,03	0,03	0,03	0,005	0,005	0,003	0,002	0,001
12 — 13	0,002	0,002	0,001	0,005	0,01	0,01	0,01	0,001	0,003	0,002	0,001	0,001

Table 3

Recurrence of wave heights and wind velocities in the Caspian Sea, %

$\overline{W}$, m/s	$h_{3\%}$, M											
	0 — 1	1 — 2	2 — 3	3 — 4	4 — 5	5 — 6	6 — 7	7 — 8	8 — 9	9 —10	10 — 11	11 — 12
2 — 4	7,34	6,82	2,59	0,78	0,22	0,15	0,03	0,001				
4 — 6	7,80	7,76	4,42	1,02	0,43	0,26	0,08	0,003	0,001			
6 — 8	6,22	7,87	2,89	1,51	0,31	0,12	0,07	0,002	0,001			
8 —10	4,32	7,95	2,80	0,71	0,17	0,06	0,01	0,007	0,002	0,002		
10 — 12	2,25	5,88	2,06	0,68	0,16	0,03	0,01	0,005	0,002	0,002		
12 — 14	1,15	3,35	1,58	0,57	0,15	0,01	0,01	0,009	0,009	0,005	0,004	
14 — 16	0,88	3,24	0,37	0,34	0,13	0,01	0,009	0,008	0,006	0,005	0,004	0,002
16 — 18	-	0,76	0,26	0,24	0,12	0,009	0,008	0,007	0,006	0,005	0,005	0,003
18 — 20	-	0,01	0,01	0,13	0,11	0,009	0,006	0,006	0,005	0,004	0,002	0,003
20 — 22	-	0,008	0,008	0,009	0,09	0,009	0,006	0,006	0,005	0,004	0,002	0,002
22 — 24	-	0,005	0,005	0,008	0,08	0,004	0,002	0,002	0,001	0,001	0,001	0,002
24 — 26	-	0,005	0,005	0,006	0,008	0,003	0,002	0,001	< 0,001	< 0,001	< 0,001	< 0,001

Table 4

Recurrence of wave heights and periods in the Black Sea, %

$\bar{\tau}$, c	$h_{3\%}$, m											
	0 — 1	1 — 2	2 — 3	3 — 4	4 — 5	5 — 6	6 — 7	7 — 8	8 — 9	9 —10	10 — 11	11 — 12
0 — 1	2,31											
1 — 2	12,10											
2 — 3	16,45	10,14										
3 — 4	8,42	9,95	3,83									
4 — 5	6,36	8,90	4,34	1,20								
5 — 6	1,72	4,12	0,85	0,33	0,26							
6 — 7	0,94	3,11	0,30	0,17	0,14	0,06						
7 — 8	0,80	0,50	0,10	0,12	0,14	0,11	0,05	0,01				
8 — 9	0,49	0,21	0,05	0,09	0,13	0,10	0,04	0,01	0,007			
9 —10	0,24	0,06	0,02	0,07	0,11	0,08	0,01	0,009	0,006	0,002	0,002	0,001
10 — 11	0,11	0,007	0,006	0,02	0,02	0,01	0,008	0,008	0,004	0,002	0,002	0,001
11 — 12	0,06	0,003	0,002	0,006	0,007	0,008	0,008	0,007	0,002	< 0,001	< 0,001	< 0,001
12 — 13	0,004	0,001	< 0,001	0,001	0,005	0,006	0,007	0,006	0,001	< 0,001	< 0,001	< 0,001

Table 5

Recurrence of wave heights and wind velocities in the Black Sea, %

$\overline{W}$, m/s	$h_{3\%}$, m											
	0 — 1	1 — 2	2 — 3	3 — 4	4 — 5	5 — 6	6 — 7	7 — 8	8 — 9	9 —10	10 — 11	11 — 12
2 — 4	16,22	2,99	1,45	0,20	0,11	0,02	0,01	0,001				
4 — 6	13,67	6,21	2,94	0,90	0,24	0,03	0,006	0,002				
6 — 8	8,87	6,46	1,72	0,76	0,09	0,07	0,02	0,01	0,001	0,001		
8 —10	5,34	5,62	1,45	0,42	0,08	0,05	0,02	0,01	0,008	0,001	0,001	
10 — 12	2,65	3,01	1,05	0,14	0,07	0,04	0,02	0,01	0,005	0,001	0,001	0,001
12 — 14	1,60	1,30	0,93	0,08	0,05	0,02	0,01	0,006	0,004	0,001	0,001	< 0,001
14 — 16	0,70	0,72	0,45	0,07	0,03	0,01	0,008	0,005	0,003	0,001	0,001	< 0,001
16 — 18	0,53	0,39	0,34	0,05	0,01	0,008	0,006	0,004	0,002	0,001	< 0,001	< 0,001
18 — 20	0,42	0,32	0,08	0,03	0,009	0,007	0,005	0,003	0,002	< 0,001	< 0,001	< 0,001
20 — 22	0,01	0,06	0,07	0,01	0,007	0,006	0,003	0,001	0,001	< 0,001	< 0,001	< 0,001
22 — 24	< 0,001	0,04	0,05	0,006	0,005	0,005	0,002	0,001	0,001	< 0,001	< 0,001	< 0,001
24 — 26	< 0,001	0,02	0,03	0,002	0,002	0,001	0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001
26 — 28	< 0,001	0,009	0,01	0,001	0,001	0,001	0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001

Table 6

Recurrence of wave heights and periods in the Barents Sea, %

$\bar{\tau}$, c	$h_{3\%}$, m													
	0 — 1	1 — 2	2 — 3	3 — 4	4 — 5	5 — 6	6 — 7	7 — 8	8 — 9	9 — 10	10 — 11	11 — 12	12 — 13	13 — 14
0 — 1	0,51													
1 — 2	1,62													
2 — 3	3,65	4,22												
3 — 4	2,75	16,18	8,03											
4 — 5	1,88	10,92	6,03	2,21										
5 — 6	0,82	3,33	5,86	5,72	3,64									
6 — 7	0,46	1,18	2,98	2,35	2,05	1,03	0,75							
7 — 8	0,15	0,59	1,73	0,99	0,43	0,35	0,21	0,19	0,08	0,06				
8 — 9	0,08	0,46	1,02	0,72	0,19	0,18	0,12	0,11	0,07	0,05	0,01	0,008		
9 — 10	0,05	0,07	0,78	0,57	0,14	0,13	0,10	0,10	0,06	0,04	0,02	0,01	0,007	0,006
10 — 11	0,01	0,03	0,44	0,32	0,06	0,06	0,05	0,05	0,02	0,02	0,02	0,01	0,008	0,003
11 — 12	0,01	0,009	0,12	0,10	0,02	0,02	0,02	0,01	0,01	0,01	0,01	0,008	0,006	0,001
12 — 13	0,006	0,007	0,007	0,009	0,01	0,01	0,01	0,01	0,01	0,009	0,007	0,006	0,005	0,001
13 — 14	0,003	0,003	0,003	0,008	0,01	0,01	0,01	0,009	0,009	0,008	0,007	0,006	0,003	< 0,001
14 — 15	0,001	0,001	0,001	0,004	0,006	0,006	0,007	0,008	0,009	0,007	0,006	0,005	0,002	< 0,001

Table 7

Recurrence of wave heights and wind velocities in the Barents Sea, %

$\overline{W}$, m/s	$h_{3\%}$, m													
	0 — 1	1 — 2	2 — 3	3 — 4	4 — 5	5 — 6	6 — 7	7 — 8	8 — 9	9 — 10	10 — 11	11 — 12	12 — 13	13 — 14
2 — 4	3,56	8,02	1,14	0,21	0,05	0,02	0,004							
4 — 6	4,67	9,56	3,51	0,56	0,45	0,10	0,07	0,04	0,03	0,009	0,002			
6 — 8	2,30	7,60	5,65	1,58	0,67	0,11	0,08	0,06	0,01	0,007	0,003			
8 —10	0,47	5,96	5,43	3,00	1,16	0,40	0,16	0,10	0,04	0,005	0,003			
10 — 12	< 0,001	3,65	4,92	2,61	0,34	0,21	0,12	0,10	0,03	0,02	0,007			
12 — 14	< 0,001	1,98	3,61	2,08	0,31	0,18	0,08	0,06	0,03	0,02	0,008			
14 — 16	< 0,001	0,23	2,04	1,97	0,23	0,17	0,05	0,04	0,03	0,02	0,001			
16 — 18	< 0,001	0,006	0,55	0,50	0,19	0,16	0,05	0,04	0,03	0,01	0,01	0,008	0,006	
18 — 20	< 0,001	< 0,001	0,15	0,32	0,16	0,15	0,04	0,03	0,03	0,01	0,01	0,01	0,005	0,001
20 — 22	< 0,001	< 0,001	< 0,001	0,09	0,09	0,08	0,04	0,03	0,02	0,01	0,01	0,01	0,004	0,002
22 — 24	< 0,001	< 0,001	< 0,001	0,07	0,06	0,06	0,03	0,02	0,02	0,01	0,01	0,008	0,004	0,002
24 — 26	< 0,001	< 0,001	< 0,001	0,01	0,01	0,01	0,01	0,01	0,02	0,01	0,01	0,008	0,003	0,001
26 — 28	< 0,001	< 0,001	< 0,001	0,005	0,006	0,007	0,008	0,009	0,009	0,009	0,009	0,007	0,003	0,001
> 28	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	0,001	0,005	0,009	0,009	0,009	0,008	0,005	0,002	0,001

Table 8

Recurrence of wave heights and periods in the Okhotsk Sea, %

$\bar{\tau}$, c	$h_{3\%}$, m														
	0 — 1	1 — 2	2 — 3	3 — 4	4 — 5	5 — 6	6 — 7	7 — 8	8 — 9	9 —10	10 — 11	11 — 12	12 — 13	13 — 14	14 — 15
0 — 1	0,15														
1 — 2	1,32														
2 — 3	1,46	1,70													
3 — 4	6,26	7,54	4,88												
4 — 5	5,54	7,22	3,99	3,56											
5 — 6	3,88	6,82	3,82	2,52	1,24										
6 — 7	0,85	5,41	2,50	1,28	0,77	0,55									
7 — 8	0,24	3,96	2,38	0,60	0,58	0,51	0,34	0,07							
8 — 9	0,12	2,48	2,32	0,45	0,26	0,22	0,11	0,14	0,05						
9 —10	0,09	1,39	1,75	0,21	0,17	0,15	0,10	0,09	0,07	0,06	0,04	0,02	0,006	0,006	
10 — 11	0,03	1,11	1,10	0,17	0,15	0,12	0,09	0,07	0,04	0,03	0,03	0,02	0,005	0,004	0,003
11 — 12	0,02	0,47	0,97	0,11	0,08	0,06	0,04	0,03	0,02	0,02	0,02	0,01	0,004	0,003	0,002
12 — 13	0,01	0,03	0,64	0,03	0,02	0,02	0,01	0,01	0,01	0,006	0,002	0,001	0,001	0,001	0,001
13 — 14	0,006	0,02	0,08	0,02	0,01	0,01	0,009	0,005	0,005	0,002	0,001	0,001	0,001	0,001	0,001
14 — 15	0,004	0,01	0,007	0,005	0,003	0,003	0,002	0,002	0,002	0,002	0,001	< 0,001	< 0,001	< 0,001	< 0,001
15 — 16	0,002	0,002	0,003	0,003	0,001	0,001	0,001	0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001
16 — 17	0,001	0,001	0,002	0,002	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001

Table 9

Recurrence of wave heights and wind velocities in the Okhotsk Sea, %

$\overline{W}$, m/s	$h_{3\%}$, m														
	0 — 1	1 — 2	2 — 3	3 — 4	4 — 5	5 — 6	6 — 7	7 — 8	8 — 9	9 — 10	10 — 11	11 — 12	12 — 13	13 — 14	14 — 15
2 — 4	3,60	13,20	2,12	0,92	0,11	0,03	0,01	0,008	0,002	0,001	0,001	0,001			
4 — 6	8,12	6,27	2,26	1,17	0,13	0,06	0,02	0,01	0,002	0,001	0,001	0,001			
6 — 8	5,00	6,43	3,69	2,41	0,31	0,08	0,05	0,02	0,005	0,003	0,003	0,001	0,001		
8 —10	2,96	7,98	3,06	1,71	1,01	0,16	0,05	0,03	0,01	0,006	0,005	0,002	0,001		
10 — 12	0,16	7,86	2,69	1,20	0,63	0,24	0,10	0,05	0,03	0,02	0,01	0,005	0,001		
12 — 14	0,14	5,18	2,34	1,03	0,55	0,42	0,14	0,11	0,03	0,02	0,02	0,005	0,001	0,001	
14 — 16	< 0,001	1,27	1,49	0,71	0,54	0,51	0,18	0,17	0,04	0,03	0,03	0,01	0,003	0,001	0,001
16 — 18	< 0,001	0,01	0,69	0,36	0,31	0,25	0,21	0,04	0,04	0,04	0,002	0,01	0,004	0,002	0,001
18 — 20	< 0,001	0,01	0,61	0,25	0,17	0,11	0,08	0,02	0,02	0,02	0,01	0,005	0,003	0,002	0,001
20 — 22	< 0,001	< 0,001	0,56	0,03	0,14	0,08	0,04	0,02	0,01	0,009	0,008	0,005	0,004	0,003	0,002
22 — 24	< 0,001	< 0,001	0,15	0,02	0,10	0,06	0,02	0,01	0,008	0,006	0,007	0,003	0,003	0,001	0,001
24 — 26	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	< 0,001	0,01	0,01	0,007	0,004	0,004	0,003	0,002	0,001	0,001

APPENDIX 2

REQUIREMENTS FOR DESIGN MODELS BASED ON FINITE ELEMENT METHOD

1 GENERAL

1.1 The calculation of a structure by the finite element method generally comprises the following stages:

definition of the type and size of a problem;

drawing up of the finite element model of a structure and boundary conditions;

simulation of loadings;

estimation of model correctness and calculation performance;

presentation of obtained results.

1.2 In modelling of a structure, boundary conditions and loading, depending on the calculation objectives and structure type, the certain assumptions and simplifications are possible and necessary. The particular potentials of a calculation are defined by the parameters of software and hard ware as well as by the size of a problem. The size of a problem may change with the accumulation of information on the peculiarities of a structure operation.

2 DEFINITION OF TYPE AND DIMENSIONS OF DESIGN MODEL

2.1 The type of a deflected state, and the size of a problem as it affects the simulation of a structure, boundary conditions and loading are to be defined.

2.2 For MODU/FOP structures, deformations and stresses are divided into the following types depending on external loadings and structure operation conditions:

general deformations and stresses in MODU/FOP structures;

local deformations and stresses in structural members;

concentration stresses and deformations in local zones of a structure and in intercostal members.

2.3 The objective of a calculation and the loading simulation technique are to comply with one of the above types of a structure deflected state.

2.4 The problem size and thus the dimensions of a design model are defined by the model boundaries selected and by the necessary dimensions of a finite element mesh.

2.5 The problem nature (linear or nonlinear) depends on structure features and deformation values. If the parameters of a structure deflected state are determined under regulated design loadings, the linear calculation is usually sufficient, particularly for thick-slab structures. Nonlinear effects are caused by material properties, large deformations and of essential importance in the following cases:

for relatively flexible structures with large deformations (geometric nonlinearity);

in investigation of partial failure of structure elements, e.g. the loss of flat panels buckling strength;

when plastic deformations in the structure area happen (physical nonlinearity).

3 STRUCTURE SIMULATION

3.1 Selection of design model types.

3.1.1 In calculations of MODU/FOP structures strength it is recommended to apply the following design models:

general model of the MODU/FOP hull;

model of a hull structure or large hull component;

model of a grillage;

framed model;

local models.

3.1.2 For all models excepting the general hull model it is to be ensured the introduction of boundary conditions for correct compliance with the conditions of interaction with adjacent structures. Where the results may adversely be affected by idealized boundary conditions, the distance between model boundaries and the structure area under consideration is to be increased.

3.1.3 The general hull model is to be used for determination of general stresses in the MODU/FOP structure. The three-dimensional simulation of the main members of a hull allows to ensure the application of loadings in the form, which is the best for simulation of a real case, and to simulate the behaviour of complex hull structures with a high accuracy.

3.1.4 The model of a hull structure or large hull component (usually a three-dimensional model) should be used for determination of general stresses in the hull part under consideration.

3.1.5 The model of a grillage is to be used for determination of general and local stresses in flat structures formed by shell plates strengthened at one or both sides with stiffeners and/or walls (grillages like a double bottom, bulkheads, decks), and also for the calculation of a transverse loading transmitted to a grillage rest and for the estimation of deformations and stresses associated with it.

3.1.6 The framed model is to be used in calculation of the strength of structures deformed (mainly, bent) in their plane, e.g. of the transverse members of the MODU pontoon, FOP underwater bearing block, etc.

3.1.7 Local models are recommended for use in calculations of the strength of separate structure elements and for determination of concentration stresses in components of structures and intercostal members.

3.2 Selection of finite elements type.

3.2.1 The type of a finite element assumed in performance of the strength calculation on each particular problem is of crucial significance. So, in selection of the finite element the recommendations given below are to be followed.

3.2.2 In calculations of structure strength the following types of elements are recommended for use:

bar elements (one-dimensional elements having axial stiffness, but without flexural stiffness);

beam elements (one-dimensional elements having axial, shear, flexural and torsional stiffness);

elements of a plane stress state (two-dimensional elements having membrane stiffness in the plate plane, but without flexural stiffness about the axes in the plate plane);

plate and shell elements (two-dimensional elements having membrane, flexural and torsional stiffness);

solid elements (three-dimensional elements);

boundary and spring elements.

When different type elements are used, emphasis should be focused on jointedness of displacements and on the possibility of ultimate loadings and stresses transfer, particularly when the elements having flexural stiffness and without it are joined in nodes.

3.2.3 The element types selected are to reflect deformations and stresses for the loading conditions under analysis and, when needed, inherent values or limit states in determination of the limit loading value.

3.2.4 It is to be defined to which extent in the given specific strength calculation the bending of structure components is to be considered. In the cases of pure bending behaviour in accordance with the theory of beam bending or plate bending, particularly for flat panels, stiffeners, grillages and transverse frames, the beam and plate elements are suitable. Where the elements of a plane stress state or solid elements are used, then for a possibility to allow for bending in the plane of the largest stiffness, the finite elements with additional intermediate nodes are to be selected or a more fine mesh be used.

3.2.5 If general deformations and stresses are only determined, the elements of a plane stress state may be used for three-dimensional models. In this case only the membrane stiffness of a simulated flat structure is considered.

3.2.6 Structural braces of minor importance, e.g. plate stiffeners, are taken into account with the degree of conditionality which is defined by the contribution of these braces into the deflected state being analyzed.

3.2.7 If brace bending in the case considered is of importance, the flexural stiffness of the brace is to be more precisely simulated (e.g. a web is simulated by flat elements, and a loose flange, by a bar or plate element). In some cases, flexural stiffness is to be taken into account by additional beam elements.

3.2.8 In other cases, stiffeners may be considered arbitrarily in the form of an additional plate thickness. As the generalized stiffness of a strengthened plate is different in mutually orthogonal directions depending on the orientation of stiffeners, it is taken into account in design models by the introduction of orthotropic properties for the plate of an effective thickness:

$$E_2 = E_1(F_{pl} + F_{st})/F_{pl}; \qquad (3.2.8)$$

$$E_1 = E$$

where E = initial modulus of elongation for a plate material;
E_1 = modulus of elasticity in the direction orthogonal to the stiffeners orientation;
E_2 = modulus of elasticity in the direction parallel to the stiffeners orientation;
F_{pl} = area of a plate cross-section;
F_{st} = area of a stiffener cross-section.

3.2.9 In local models, all stiffness components including the secondary ones, are of a significant importance; this being so, the plate, shell and solid elements are used. Exception may relate to flat structures loaded in its plane. For instance, in analysis of concentration stresses at cutout edges they are simulated by the plates of a plane stress state.

3.2.10 In order to obtain the information on deformations between two nodes, e.g. at free edges of a plate, the bar elements of a negligible cross-section should be introduced. Uniaxial stresses of such an element present edge stresses.

3.3 Break-down into finite elements.

3.3.1 The size of a finite element mesh is defined by the characteristics of finite elements and to be selected subject to sufficient accuracy in simulation of:

the stiffness parameters of a structure;

the type of stresses analyzed;

potential failure forms.

The recommendations given below are to be followed while selecting the dimensions of the finite element mesh.

3.3.2 In selection of a finite element mesh the structure geometry, loading disposition and nature, and supports layout are to be properly taken into account.

3.3.3 The three-dimensional models of a structure at large or parts of the structure may have a rather gross idealization. As the characteristic size of a finite element may be used the frame spacings of the main structure components. It is allowable in calculations of a general stress state provided that the flexural behaviour of the main structure components is reflected by the selected type of a finite element with an adequate accuracy. The same relates to grillage models and to the models for the calculation of local strength of stiffeners if the width of elements in shell plates is equal to the stiffeners spacing or its half.

3.3.4 The element characteristics and its dimensions are to be so selected that stiffness, resulting deformations and stresses may properly reflect the structure behaviour. For simple finite elements the ratio of element side dimensions is usually not to be more than three.

3.3.5 In computation of local concentration stresses the size of a finite element mesh is to be varied gradually in accordance with the stress gradient expected.

3.4 Introduction of simplifying assumptions.

3.4.1 Due to the complexity of a MODU/FOP structure the assumptions aimed at simplifications should be introduced in simulation. Simplifications are acceptable if they do not give rise to significant errors in the results.

3.4.2 A typical simplification in general strength calculation is the integration of several components of a structure into a single one. Integration may concern stiffeners or beams. Integrated components are to have an equivalent stiffness and be placed in the geometrical centre of composing components.

3.4.3 Small components and pieces, which define the stiffness of small parts, may be completely ignored in simulation. The example of such components and pieces for the calculation of general strength is small cutouts, frame brackets, stiffeners, reinforcements which prevent buckling.

3.4.4 Large cutouts (cutouts for access into internal spaces, windows and doors) are always to be taken into account. With a structurally stable finite element mesh, such cutouts are taken into account by the stiffness reduction at the expense of the element thickness reduction or the reduction of a modulus of rigidity and a modulus of elongation in longitudinal and transverse directions.

3.4.5 Flat elements are to be placed in the middle surface of the relevant components of a structure. For the analysis of general strength of thin-walled structures, the elements, as an approximation, may be arranged along the lines of an external surface.

3.4.6 Flat two-dimensional elements in inclined or curved surfaces are usually to be placed in the geometrical centre of the area simulated in order to reflect with the greater accuracy general stiffness characteristics

3.5 Boundary conditions and fixings.

3.5.1 Assignment of boundary conditions and fixings is intended for:

elimination of displacements and turns of a model as a rigid entity;

allowing in a design model for actually existing supports and fixings;

allowing for the interaction of the model for the part of a structure along its boundaries with adjacent parts.

Kinematic boundary conditions and fixings are introduced by the assignment of prescribed values for displacements and turning angles in nodal points of a design model. In introduction of fixings the appearance in the model of nonexistent, in actual behaviour of a structure, restrictions for displacements and turning angles are to be avoided.

3.5.2 The exception of displacements and turns of a model as a rigid body (FEM programs do not ensure the automatic exception of such displacements) is to be materialized by means of introduction of supports or fixings in various sections of the model. The reactions at these supports and fixings that are lacking in actual structures are to be kept to a minimum by means of loading the model by a self-balanced system of loads. The displacements and turns of a solid body may be eliminated by introduction in the design model of a distributed elastic foundation by means of spring elements what, for instance, may closely agree with the actual conditions of a FOP position on seabed or the conditions of a FOP hull position afloat.

3.5.3 Actual supports that take forces and moments are to be simulated with the high degree of approximation to actual conditions.

3.5.4 The interaction of hull structure parts with adjacent structures along the model boundaries is to be simulated with the possibly high degree of approximation to a reality. The structure symmetry is to be taken into account and the model is to be developed for its symmetric part only. The conditions of a symmetric and antisymmetric deformation are introduced across symmetry planes and a loading is resolved into symmetric and antisymmetric components. The interaction along a boundary is to be taken into account by the relevant assignment of stresses, forces and moments. These values are obtained as the result of a structure calculation according to a general model.

3.5.5 In use of some element types the need, due to nonexistent stiffness, in suppressing degrees of freedom in nodes may arise. In doing so, the restrictions of actual deformations are not allowed. If, with degrees of freedom suppressed, the elements give additional stiffness, their dimensions are to be so selected that they may provide the stiffness reasonably reflecting actual behaviour.

4 LOADING SIMULATION

4.1 Loadings are to be simulated with a high degree of approximation to a reality. When needed, structure simulation is to be adapted for loading simulation.

4.2 Distributed loadings during calculations are converted into equivalent nodal forces and into nodal moments in accordance with the finite element type in use.

4.3 If the deformations along the boundary of a local model are obtained from the calculation according to the general model of a structure with a structurally stable mesh, the relevant interpolation of a deformation for the intermediate nodes of the local model is to be used. In addition, the relevant loadings acting within the local area of the structure are to be applied.

5 ASSESSMENT OF RESULTS VALIDITY

5.1 The results are to be verified for validity. Such a verification includes:

special visual display of deformation for the assessment of their distribution compliance with the loadings applied, boundary conditions, supports and fixings;

check of compliance of the deformation values obtained with the range expected.

5.2 It is to be checked whether the values of forces and moments at supports comply with the values expected. For self-balanced loadings it is to be checked whether reaction forces are small enough to be negligible.

5.3 For local models with preassigned deformations at a boundary obtained from the general models of structures, the mutual compliance of the stress near the boundaries in question for two models is to be checked.

5.4 For nonlinear calculations the exactness of a solution in a nonlinear zone is to be checked.

PART III. EQUIPMENT, ARRANGEMENTS AND OUTFIT OF MODU/FOP

1 GENERAL

1.1 APPLICATION

1.1.1 All the requirements of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships apply to MODU and FOP, unless expressly provided otherwise in the present Part.

1.1.2 The requirements of the present Part do not cover the following arrangements and equipment:

industrial machinery used exclusively in drilling and related operations as well as in output processing;

mooring equipment (other than the mooring equipment of drilling ships).

1.1.3 Equipment, arrangements and outfit of drilling ships are to be in full compliance with the requirements of Part III "Equipment, Arrangements and Outfit " of the Rules for the Classification and Construction of Sea-Going Ships and with expressly specified requirements of MODU/FOP Rules.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 The definitions and explanations relating to general terminology are given in General Regulations for the Classification and Other Activity, in Part I "Classification" and in Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships, as well as in Part I "Classification" and Part II "Hull" of MODU/FOP Rules.

For the purpose of this Part, the following definitions have been adopted.

Unit means a MODU, FOP, FOP modules and/or any elements thereof.

Length of unit means the length of the hull measured at the level of the waterline appropriate to the unit's maximum draught while afloat in transit.

Breadth of unit's hull means the extreme moulded breadth of the hull measured at its mid length at the level of or below the waterline in transit.

Draught means a vertical distance measured at the midpoint of the appropriate length of the unit from the top of the plate keel or from the point where the inner surface of the shell (outer surface for units with a non-metal shell) abuts upon the bar keel, up to the relevant waterline of the unit.

Hull is a watertight structure, which ensures buoyancy and stability of the unit. The hull may include one, two or more lower hulls (pontoons) generally immersed in water and an upper hull, which is usually above water.

Upper deck (UD) is a watertight structure bounding the hull from the top, from which the freeboard is measured.

Upper structure (US) is a construction comprising superstructures, deckhouses and other similar structures used for crew's accommodation and arrangement of equipment, appliances and systems providing functioning of the unit according to its intended purpose.

US normally consists of modules.

Supporting assembly (SA) is a carrying structure providing support and resistance of a unit against external effects when placed on the seabed. The lower hull/hulls may stand duty as the supporting assembly.

Supporting deck (SD) is the construction on which the upper structure is installed.

Module is generally defined as a hull, supporting assembly, upper structure and/or parts thereof, being a transport unit whose state afloat may be considered as short-time and relating to their outfitting and/or transportation periods.

It is assumed that a possibility for the module to be exposed to extreme ambient conditions is obviously eliminated.

Watertightness means the capability of a structure to prevent water penetration in any direction under the water head the structure is designed for.

Dynamic positioning system is a system intended for the automatic and remote automated control of MODU propulsion machinery in order to ensure MODU dynamic position keeping at predetermined accuracy when exposed to external effects.

Margin line means a waterline down to which a unit is submerged after damages specified in Part V "Subdivision" of MODU/FOP Rules.

Compartment is the part of the hull interior bounded by shell plating, watertight bulkheads, decks, platforms, stringers and floors.

1.3 SCOPE OF SUPERVISION

1.3.1 General regulations on supervision of equipment, arrangements and outfit are given in General Regulations for the Classification and Other Activity and in Part I "Classification of the Rules for the Classification and Construction of Sea-Going Ships, as well as in Part I "Classification" of MODU/FOP Rules.

1.3.2 The scope of supervision of products included into equipment, arrangements and outfit of MODU/FOP is to be in compliance with the list given in 1.3, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships as far as applicable to the particular type of MODU/FOP, taking into account the additional arrangements listed below.

1.3.2.1 Jacking arrangements of self-elevating unit:

.1 hydraulic, with legs of space truss type: sliders, catches, yokes for securing hydraulic cylinders, slider guides, catch bearers, securing plates of hydraulic cylinders, support screws with nuts, fastenings (bolts, pins, nuts);

.2 hydraulic, with legs of cylinder type: moving and fixed yokes (in relation to the self-elevating unit hull), yoke catchers, support screws with nuts, fastenings (bolts, pins, nuts);

.3 mechanical, rack-and-pinion type: jack frame, rack-and-pinion shaft, pinions, gear wheels, shafts, fastenings (bolts, pins, nuts).

1.3.2.2 Arrangements for lifting and lowering columns of submersible sea water pumps:

.1 columns and guides;

.2 stoppers;

.3 fastenings (bolts, pins and nuts).

1.3.2.3 Fixing arrangements of self-elevating units (if any):

.1 plates;

.2 screws and nuts.

1.3.2.4 Closing arrangements of well cementing ports for passage of cathodic protection cables and for inspection of submersible sea water pumps:

.1 manholes;

.2 covers.

1.3.3 The items of equipment, arrangements and outfit listed in 1.3, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships and in Table 1.3.3 of the present Part are subject to control by the Register with respect to fulfillment of the requirements of Part XIII "Materials", Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships, as well as Part IX "Materials" and Part X "Welding" of MODU/FOP Rules.

Table 1.3.3

Nos.	Item[1]	Blanks	Scope of test[2]
1	Catches, catch bearers, slider casings, slider guides, support screws, support screw nuts, pins of yoke catches, fastenings (bolts, pins, nuts), jacking system for hull of MODU; screws and nuts of fixing arrangements (if any), axles for securing of lifting hydraulic cylinders	Steel forgings Steel castings	3.7 3.8
2	Rack-and-pinion shafts, pinions, shafts of jacking system	Steel forgings	3.7
3	Yokes for securing of hydraulic cylinders, pin casings of catching devices and gear wheels of jacking system of the MODU	Steel castings	3.8
4	Moving and fixed yokes of jacking system of the MODU	Rolled steel	3.2
5	Securing plates of cylinders of jacking system of the MODU; plates of fixing arrangements (if any)	Steel plates	3.2
6	Frames and portals of mechanical jacks of jacking system of the MODU	Steel plates and shapes	3.2

[1]The use of other materials for items listed in the Table is subject to special consideration by the Register.
[2] The scope of test is in accordance with the stated sections of Part XIII "Materials"of the Rules for the Classification and Construction of Sea-Going Ships.

1.3.4 The following equipment, arrangements and outfit are subject to the Register supervision during construction of the MODU in accordance with the requirements of relevant chapters of the Rules for the Classification and Construction of Sea-Going Ships and MODU/FOP Rules:

.1 rudder and steering gear;

.2 anchor arrangement;

.3 towing arrangement;

.4 openings in hull, superstructures and deck-houses and their closing arrangements;

.5 jacking system for hull of self-elevating units;

.6 arrangements for lifting and lowering columns of submersible sea water pumps;

.7 fixing arrangements of self-elevating units (if any);

.8 masts and their rigging;

.9 arrangement and equipment of spaces;

.10 emergency outfit;

.11 systems intended to maintain MODU on station and their components.

1.3.5 The following equipment, arrangements and outfit are subject to the Register supervision during construction of the FOP in accordance with the requirements of relevant chapters of the Rules for the Classification and Construction of Sea-Going Ships and MODU/FOP Rules:

.1 systems intended to maintain FOP on station and their components;

.2 openings in hull of the FOP and their closing arrangements;

.3 masts and their rigging;

.4 arrangement and equipment of spaces;

.5 emergency outfit;

.6 mooring and boarding arrangements.

2 RUDDER AND STEERING GEAR

2.1 GENERAL

2.1.1 The self-propelled MODU are to be provided with a reliable rudder and steering system ensuring their steering and course-keeping qualities with due regard for the operating conditions of the MODU and complying with the requirements of Section 2, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships.

2.1.2 On non-self-propelled units the Register may allow to omit the steering gear or to provide only stabilizers; however, this omission is subject to special consideration by the Register.

2.1.3 Self-propelled MODU equipped with rudders are to be provided with an access (passage) which makes it possible to determine technical condition of the rudder bearings and clearances in the latter as well as to make sure that all connections of the rudder pintles with gudgeons are undamaged and secured.

To ensure access, if necessary, provision is to be made for bolted plating.

3 ANCHOR ARRANGEMENT

3.1 GENERAL

3.1.1 For the period of operations at sea (in particular, when moving to the station) each MODU/FOP is to be generally provided with anchor arrangement specified in 3.1.1, Part III "Equipment, Arrangements and Outfit" of Rules for the Classification and Construction of Sea-Going Ships", intended for temporary station-keeping of MODU/FOP at sea, and ensuring, if necessary, holding anchorage under stormy conditions which severity is in excess of that permissible for operations at sea.

On agreement with the Register and if specially justified, MODU/FOP may be not provided with an anchor arrangement. In this case, to ensure temporary station-keeping of MODU/FOP consideration may be given to anchor arrangements of tow order vessels. Thereby detailed results of calculations and justifications for ensuring holding anchorage under stormy conditions including the characteristics of support vessels, safety factors, environmental effects and loads are to be submitted to the Register.

For MODU, it is permitted to use the positioning system as the anchor arrangement.

3.1.2 For bower anchors of MODU/FOP, considering temporary nature of the anchor arrangement operation and the possible anchorage depths, it is permitted to include wire and synthetic fibre ropes into the anchor arrangement.

3.1.3 The need for provision of stoppers to secure the anchors for sea is subject to special consideration by the Register.

3.1.4 The anchor arrangement of FOP may be located on the hull or on special overhang platforms installed for the period of operations at sea. Considering the temporary nature of the anchor arrangement operation, it is reasonable to provide the use of individual items of the anchor arrangement (machinery, hawse pipes, holders, etc.) for other purposes during operation of MODU (as the mooring and other arrangements).

3.1.5 If provision is made for installation of the anchor arrangement, the anchor equipment of MODU/FOP is to be selected from Table 3.1.3-1, Part III "Equipment, Arrangements and Outfit" of Rules for the Classification and Construction of Sea-Going Ships according to the equipment number determined in accordance with 3.2 of the present Part of MODU/FOP Rules, where the equipment number obtained does not exceed values given in the said Table.

Where the equipment numbers exceed tabulated values given in Rules for the Classification and Construction of Sea-Going Ships, the anchor equipment of MODU/FOP is to be determined by special calculations, based on natural conditions and loads corresponding to the possible conditions for performance of operations at sea, having regard to additional station-keeping of MODU/FOP ensured by tow order vessels. In such a case, it is recommended to assume the design parameters of environmental effects by 15 to 20 per cent higher than those which are assumed when determining the total pull of tow order vessels.

3.1.6 MODU/FOP, as a rule, are to be equipped with not more than two anchors. For prolonged towings at sea under severe natural conditions, it is necessary to provide a spare set of the anchor arrangement items (anchor, anchor cable, joining devices, etc.) which may be carried on MODU/FOP or on tow order vessels.

3.1.7 For drilling ships, the anchor equipment is to be selected from Table 3.1.3-1 according to the equipment number determined by the Formula (3.2.1-1), Part III "Equipment, Arrangements and Outfit" of Rules for the Classification and Construction of Sea-Going Ships.

3.2 EQUIPMENT NUMBER

3.2.1 The equipment number used for selection of anchor equipment of MODU/FOP is to be determined by the formula

$$N_C = K_1 K_2 \Delta^{2/3} + K_3 A \qquad (3.2.1)$$

where K_1, K_2, K_3 = coefficients accounting for the form of the hull, effect of waves and wind conditions at the anchorage, respectively;

Δ = volume displacement of MODU/FOP or FOP moduls sections at the given draft (or to the centre of the load line mark), in m^3;

A = total projected area of the structures above the waterline (passing through the centre of the load line mark) on the plane normal to the horizontal projection of the anchor line, in m^2.

3.2.2 The form coefficient K_1 is to be taken equal to:

1,5 for drilling units with pontoons of rectangular shape and FOP/FOP modules;

1,75 for drilling catamarans and units of similar types.

The coefficient K_1 may be also obtained from the ratio R/R', where R' and R are resistances of the submerged part of a conventional ship and a drilling unit, FOP/FOP modules, with the same displacement, respectively.

The coefficients K_2 and K_3 are taken from Table 3.2.2.

Table 3.2.2

MODU/FOP	K_2	K_3
Open sea	1,2	2,1
Enclosed sea	1,1	1,8

3.2.3 In well-grounded cases the Register may accept other values of coefficients given in 3.2.2 provided it is proved that the proposed values are in agreement with the actual service conditions.

3.2.4 The application of other calculation methods for anchor equipment is subject to special consideration by the Register.

In this case, detailed data on construction, characteristics of items and location of the anchor arrangement on MODU/FOP, justifications, methods, calculation results, accepted safety factors, design parameters of holding anchorage under stormy conditions, consideration of additional station-keeping due to operation of the tow order are to be submitted to the Register.

3.3 ANCHORS, CHAIN CABLES AND ROPES FOR ANCHORS, ANCHOR EQUIPMENT AND MACHINERY

3.3.1 Anchors, chain cables and ropes for anchors, anchor equipment and machinery are to comply with the requirements of 3.3.2, 3.3.3, 3.4.4 to 3.4.9, 3.4.12, 3.6.1 to 3.6.4, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships, respectively.

It is allowed to use in a MODU/FOP chain cables with intermediate lengths of a continuous length and strength grade according to 7.2, Part XIII "Materials" of Rules for the Classification and Construction of Sea-Going Ships.

3.3.2 A chain cable may be replaced with a wire rope except for the anchor length and the next section of a common link chain.

In this case the total length of the chain cable portion is to be equal to the distance between the anchor machinery and the point of securing the anchor for sea, but it is not to be less than 12,5 m.

The breaking strength of such ropes is to be generally not less than the breaking load of the corresponding chain and their length is not to be less than 1,5 times the length of these chain cables.

Equipment and machinery are to ensure the required wire rope tension during anchor stowage and during station-keeping of the unit to preclude formation of sheepshank knots on the rope.

3.3.3 Use of synthetic fibre ropes in the anchor arrangement of MODU/FOP is subject to special consideration by the Register.

3.3.4 When selecting the anchor arrangement on the basis of special calculations, the anchor characteristics (type, mass) are to be determined on the assumption that they will ensure the required holding power. The holding power of the anchor is to be determined under design parameters of holding anchorage under stormy conditions with a safety factor within the range from 0,8 up to 1,0. In this case, the anchor rope tension is not to exceed the permissible value considering the safety factor which is recommended to be taken not less than 1,7.

3.3.5 If specially justified, FOP may be not equipped with anchor machinery where the carriage, dropping and heaving of anchors are provided by auxiliary of tow order vessels.

3.3.6 Anchors, chain cables and ropes are to be manufactured in compliance with the requirements of Appendices 1 — 3 to Part IV "Technical Supervision during Manufacture of Materials" of Rules for Technical Supervision of Ships and Manufacture of Materials and Products for Ships and Sections 3 and 7, Part XIII "Materials" of Rules for the Classification and Construction of Sea-Going Ships. The use of chain cables of higher strength is subject to special consideration by the Register.

4 SYSTEMS USED TO MAINTAIN MODU/FOP AT DRILLING/POSITIONING SITE AND THEIR COMPONENTS

4.1 GENERAL

4.1.1 The requirements of the present Section apply to passive and active positioning systems intended for station-keeping of MODU/FOP (afloat) with restriction of shiftings within the prescribed limits and ensuring of normal conditions to perform technological processes and works at the station (drilling, production, loading of solid ballast, outfitting, etc.).

The requirements cover the following:

.1 anchoring systems for station-keeping (positioning) of MODU/FOP afloat, including anchors and flexible anchor links;

.2 dynamic positioning systems enabling station positioning of MODU with the use of specially installed thrusters.

4.1.2 The requirements of the present Section also apply to distributed anchoring systems ensuring station-keeping of mast type FOP/tension leg type FOP with the use of slack or taut anchor lines.

4.1.3 When developing anchoring positioning systems, consideration is to be given to the requirements of Part II "Hull" and Part IV "Stability" of MODU/FOP Rules which may be affected by the positioning system operation.

4.2 ANCHORING SYSTEMS

4.2.1 The anchoring MODU/FOP positioning systems include, as a rule, several separate anchor arrangements each consisting generally of the following components:

.1 a complex of fittings, machinery and devices on MODU/FOP;

.2 anchor lines;

.3 anchor supports.

The composition and characteristics of the components of the anchor arrangements and anchoring system as a whole are subject to special consideration by the Register in each case.

4.2.2 The Register is to be provided with documentation showing location and containing detailed specification of anchoring system including anchors, connecting shackles, anchor lines consisting of chain, wire, synthetic or fibre rope as well as drawings of fairleads, guide devices, windlasses and other components of anchoring systems and their foundations.

4.2.3 The Register is to be additionally provided with:

.1 calculation of anchoring system including determination of the number of anchor lines which are to be used in operation of the MODU/FOP and during emergency situations, mass and type of anchor;

.2 breaking strength calculation for the anchor line. Material specifications of the anchor line;

.3 design and calculation of the anchor and anchor shackle unless they are of a type which has been previously approved;

.4 design of the anchor line stopper. Material specifications;

.5 design of guiding devices of the anchor line. Material specifications;

.6 design ofchain/rope connections (if any). Type and design of connection of the rope and anchor shackle, if any. Material specifications;

.7 foundations and strengthening.

.8 design and calculations of special components used as a part of anchor lines and anchor arrangements (buoyancy elements, weights, corrosion protection systems, shock-absorbing inserts, etc.), if any.

4.3 CONSTRUCTION

4.3.1 The anchoring system is to be so designed that movements of MODU/FOP and forces (stresses) arising in the components as well as sudden failure of any anchor line will not cause damages to the hull and progressive failure of the remaining anchor lines.

The anchoring system as a whole is to ensure station-keeping of MODU/FOP in case of breaking of one (any one or the most loaded one) anchor line up to its restoration.

4.3.2 The components and devices are to be arranged on the MODU/FOP hull in such a way as to provide access for inspection and repair. For the devices inaccessible for inspection and repair, special requirements for reliability and service time are to be specified.

4.3.3 When designing anchoring systems, safety factors are to be determined for normal operational condition, survival condition under extreme factors and for conditions where damages of MODU/FOP are likely to occur.

Safety factors criteria are to be established in the design considering the recommendations of the recognized norms (standards) and the probability of occurrence of the ultimate condition under consideration. The quantitative values of safety criteria are to define the necessary margin in order to preclude hazardous (ultimate) condition in terms of fatigue and ultimate strength, buckling, rigidity, deformation of the anchoring system components and ultimate movements, speeds and accelerations of MODU/FOP.

4.3.4 When designing anchoring systems of MODU/FOP, consideration is to be given to various rated operational and extreme levels of weather effects:

.1 calm weather conditions ("weather window") – conditions characterized by relatively slight environmental effects and making it possible to perform safely various technological operations and works including complicated ones;

.2 operational weather conditions — conditions characterized by frequent recurrence during service period and restricting only performance of some complicated technological operations and works;

.3 stormy weather conditions — conditions with unfrequent recurrence during service period, which are ultimate for performance of technological operations;

.4 extreme weather conditions — conditions with low probability of exceedance during service period, which are permissible for the anchoring system.

The quantitative indices of the weather effects levels are to be correlated with the safety factors used in the design.

The quantitative values of the first three levels of weather effects (values of wind, waves, currents and tidal effects) are to be determined proceeding from the operational requirements and restrictions on MODU/FOP behaviour, which ensure performance of particular technological operations.

The extreme weather conditions are to be taken, based on risk analysis considering the recurrence of environmental effects, service time of MODU/FOP at the station and in accordance with the general requirements of 2.3, Part II "Hull" of MODU/FOP Rules. If specially justified, the recurrence of rated effects may be reduced as against the requirements mentioned above. In this case, detailed results of justifications are to be submitted to the Register.

4.3.5 It is recommended to design the anchoring MODU/FOP positioning systems in the following sequence:

.1 to pre-select the dimensions and characteristics of the anchoring system components;

.2 to determine safety factors and criteria for various operating conditions;

.3 to identify possible combinations of environmental effects and phenomena typical for the prescribed station of MODU/FOP;

.4 to justify the rated levels of weather effects and operating conditions proceeding from the requirements for the reliable station-keeping of MODU/FOP, technological, communication and other requirements and recurrence of environmental effects;

.5 to determine the parameters of environmental loads for rated conditions;

.6 to do the calculations of MODU/FOP behaviour with determination of forces (tensions, loads) in the anchoring system components;

.7 to compare the criteria obtained from the calculation with the safety criteria;

.8 if necessary, to define more exactly the anchoring system characteristics.

When doing calculations, consideration is to be given to various MODU/FOP loading conditions, including the case of compartment flooding, and various pre-tension values of anchor lines because they affect significantly the fulfilment of operational requirements for restriction of movements.

It is recommended to do the calculations successively for static loads, dynamic effects and cyclic loads. Where necessary, calculations of vibrations and dynamics of anchor lines may be done.

4.3.6 The developed design to be submitted to the Register is to include final calculation of the anchoring systems which are intended for use during operation of MODU/FOP considering safety factors and environmental conditions.

The calculation is to take into account the following factors:

.1 rated environmental conditions, such as waves, winds, currents, ebb tides and flood tides, depths;

.2 air and water temperatures;

.3 ice conditions (if any);

.4 seabed configuration;

.5 geologic and technical conditions of the water area bed.

4.3.7 Calculations of anchoring systems may be made using both the deterministic and the statistic (probabilistic) approach.

When using the deterministic approach, parameters of the rated operational and extreme phenomena are to be initially determined (see 4.3.4). For the said phenomena the relevant values of loads and effects the anchoring system is designed for are to be determined.

When using the probabilistic approach, combinations of all kinds of weather conditions and phenomena are to be initially determined. Calculations of the anchor system and statistic analysis of reactions are to be done for all these combinations.

Calculations of reactions in anchor links and the movements of MODU/FOP may be done by quasi-static or dynamic methods. When using the quasi-static method, effects of wind, current and wave drift force components are treated as static forces and the wave disturbing forces which induce motions are treated as harmonic loads with wave frequency. The methods are generally to take into account the dynamic nature of the effect, six degrees of freedom of the structures, inertia forces, influence exerted by friction forces and non-linear effects resulted from both physical and geometrical non-linearity. For anchoring systems in operation over a long period of time, calculations for cyclic loads and analysis of strength considering the endurance limit of components are to be done. For taut anchor lines the influence of vibrations which can be produced by eddies formed in water flow under the effect of current and waves is to be assessed.

Based on the calculation results, it is necessary to determine the maximum and minimum forces (tensions) in the system components, movements, speeds and accelerations of MODU/FOP under various environmental effects, as well as the rated service life of anchor lines. The rated values of these parameters are to be compared with safety criteria (strength, buckling, fatigue strength, operational restrictions).

4.3.8 The anchoring system components are to be designed with due regard for the adequate safety factors and with the use of methods allowing to identify extreme loading conditions for each component. In particular, consideration is to be given to a sufficient number of course angles along with the most unfavourable combination of wind, current and waves acting generally in one direction in order to determine the maximum tension of each anchor line.

When treating a certain station where MODU/FOP is positioned, consideration is to be given also to any applicable patterns of irregular waves if they can result in increased loads.

4.3.9 When a quasi-static method is used, the maximum tension of each anchor line is to be calculated for the maximum deviation from each rated condition given in 4.3.10, combining with each other the following static and dynamic characteristics of MODU/FOP:

.1 mean steady shifting under the effect of a certain wind, current and wave drift forces;

.2 the most probable maximum movement (amplitude of oscillations) of MODU/FOP lying at anchor under the effect of waves due to wave excitation;

.3 effect of damping and inertia forces exerted on anchor lines is to be allowed for in the calculation, as applied to considerably greater depths;

.4 effect of the slowly changing movement is to be allowed for when the magnitude of such movement seems to be considerable.

4.3.10 When using the quasi-static method mentioned in 4.3.9 consideration is to be given to the following minimum safety factors at the maximum deviation of MODU/FOP from the nominal values in a broad range of directions (see Table 4.3.10).

Table 4.3.10

Design condition	Safety factor (SF) used in quasi-static method of calculation
Operation	2,7
Operation under severe storm conditions	1,8
Operation with one anchor line failed	1,8
Operation under severe storm conditions with one anchor line failed	1,25

$$SF = RV/T_{max}$$

where T_{max} = anchor line tension characteristic equal to the maximum value obtained according to 4.3.9;

RV = minimum design breaking strength of the anchor line.

Operation is the most rigorous design weather conditions of normal operation established by the owner or designer.

Operation under severe storm conditions is the most rigorous design conditions of severe storm established by the owner or designer.

Operation with one anchor line failed is a condition after breaking of any anchor line in operation.

Operation under severe storm conditions with one anchor line failed is a condition after breaking of any anchor line in severe storm.

4.3.11 When doing dynamic calculation, the minimum safety factors for the maximum tension of anchor lines according to Table 4.3.11 as well as other safety factors satisfying the Register may be taken into consideration.

Table 4.3.11

Design condition	Safety factor (SF) used in dynamic method of calculation
Operation	2,0
Operation under severe storm conditions	1,5
Operation with one anchor line failed	1,5
Operation under severe storm conditions with one anchor line failed	1,05

$SF = RV/T_{max}$

where T_{max} = anchor line tension characteristic equal to the maximum value obtained when the dynamic method of calculation is used;

RV = maximum design breaking strength of the anchor line.

Definitions of operational terms are given in Table 4.3.10.

The conditions of operation and severe storm as defined above are to be taken into account in the designs of MODU/FOP, except for the cases when the Register considers it possible to apply less severe requirements in certain areas of the shelf.

4.3.12 As a rule, the maximum movement of MODU/FOP lying at anchor under the effect of waves at continuous mean shifting is to be determined by model tests.

When considering column-stabilized MODU, values of C_{Sj} and C_{Hj} given in Part IV "Stability" of MODU/FOP Rules may be included into the analysis of anchoring systems enabling the unit to be maintained at the drilling site. As an alternative to the calculation methods for determination of the wind load given in Part IV "Stability" of MODU/FOP Rules, the Register may take into account the values of the wind capsizing moments obtained from the wind tunnel tests according to the recognized methods.

The Register may accept analytical calculations subject to the condition that the calculation method submitted is based on the recognized methods verified by model tests.

4.3.13 The Register may accept various calculation methods for the maximum tension (loads) of the anchor line components provided that the safety level required by 4.3.9 to 4.3.11 is ensured.

4.3.14 The values of the maximum MODU/FOP movements, obtained from the calculation are to meet the condition:

$$x_u/x \geqslant k \qquad (4.3.14)$$

where x_u = ultimate values of MODU/FOP movements established by the requirements of the design and the operating rules for the equipment;

x = maximum rated movements for the rated operating mode under consideration;

k = safety factor the value of which may be taken equal to 1,15 when the quasi-static method is used and equal to 1,05 when the dynamic method is used.

4.3.15 The fatigue endurance level of anchor lines, determined by the calculations, is to be not less than thrice the rated service life of the anchoring system. When there are no true data on fatigue curves and when access for inspections and repair cannot be provided, the Register may require a higher endurance level.

4.3.16 The holding power of the ship type anchor for MODU/FOP intended for operation at one station throughout the whole service life is to be determined at design parameters of holding anchorage under stormy conditions with the following safety factors:

.1 not less than 1,8 when the quasi-static method is used;

.2 not less than 1,5 when dynamic method is used for calculation of MODU/FOP in intact condition and the anchoring positioning system;

.3 not less than 1,2 when the quasi-static method is used and 1,0 when dynamic method is used for calculation of MODU/FOP in damaged condition or the anchoring positioning system.

4.3.17 For MODU/FOP which can be used at different stations throughout their service life as well as for the non-ship-type anchors, determination of holding power and safety factors values are subject to special consideration by the Register.

4.3.18 The Register may specially consider a case in which the anchoring systems are used in conjunction with thrusters to maintain the MODU at drilling site.

4.4 EQUIPMENT

4.4.1 Winches.

4.4.1.1 The design of the winch is to provide for adequate dynamic braking capacity to control normal combinations of loads from the anchor, anchor line and anchor handling vessel during deployment of the anchors at the maximum design pay out speed of the winch.

The attachments to the hull are to be such as to adequately withstand the load equal to the breaking strength of the anchor line.

4.4.1.2 Each winch is to be provided with two independent power-operated brakes. Each brake is to be capable of holding against a static load in the anchor line of at least 50 per cent of its breaking strength.

When the Register so allows, one of the brakes may be replaced by a manually operated brake.

4.4.1.3 On loss of power to the winches, the power-operated braking system is to be automatically applied and capable of holding against 50 per cent of the total static braking capacity of the winch.

4.4.2 Anchor line tensioning devices.

4.4.2.1 The anchor line tensioning devices are to be designed to take up the design combined load from the anchor and anchor line.

4.4.2.2 Each anchor line tensioning devices is to be provided with a power-operated stopper capable of withstanding a static load in the anchor line of at least 80 per cent of its breaking strength.

4.4.2.3 The attachments of the anchor line tensioning devices to the MODU/FOP hull are to be such as to adequately withstand the load equal to the breaking strength of the anchor line.

4.4.3 Fairleads and guiding devices.

4.4.3.1 Fairleads and guiding devices are to be designed to prevent excessive bending and wear of the anchor line. The attachments to the hull are to be such as to adequately withstand the stresses imposed when the anchor line is loaded to its breaking strength.

4.4.3.2 Guides are to be of roller type. The guide roller is to be provided with a turning device.

4.4.3.3 From the guide roller, the chain is to run directly to the chain sprocket of the winch or the tensioner stopper without passing through an additional guide.

Provision of an additional guide is subject to special consideration by the Register.

4.4.3.4 The number of chain link pockets to be provided in the chain guide rollers is not to be less than 5.

In case of guide rollers for wire ropes, the ratio of the roller groove diameter to the nominal rope diameter is not to be less than 16.

4.4.3.5 The guides for the combined rope-and-chain anchor lines are subject to special consideration by the Register.

4.4.3.6 In calculation, the rated stresses in the structural components of the guide are not to exceed 0,9 times the yield stress of the material when subjected to the breaking load of the anchor line. The strength calculation is to be made for the most unfavourable direction of the anchor line.

Consideration in the calculation is to be given to the design working range of the roller turning angles in horizontal plane and the design anchor line departure angle in vertical plane.

4.5 ANCHOR LINES

4.5.1 The Register is to be satisfied that the anchor lines have been designed to meet the design parameters of the anchoring system.

4.5.2 Means are to be provided to enable the anchor line to be released after loss of main power.

4.5.3 Means are to be provided to measure anchor line tension.

4.5.4 Anchor lines are to be of sufficient length to prevent hoisting of the anchor in the extreme cases foreseen in the anticipated operating conditions.

4.5.5 Anchor lines may be of chain, wire, synthetic or fibre rope or any combination thereof.

Chains for anchor lines are to meet the requirements of 3.3.1.

4.5.6 Diameters of the chain cables or ropes used in the anchor line are to be consistent with the breaking load of the anchor line according to the ultimate strength and fatigue strength calculations which are to allow for the wear and corrosion of the chain cables and ropes.

4.5.7 Connections between the anchor line components and the attachments to other components (anchors and hull) are to be designed with due regard for the alignment of the components being connected and with smooth transitions to preclude stress concentration.

4.6 ANCHORS

4.6.1 Type and design of the anchors are to be approved by the Register.

4.6.2 As a rule, anchors of the FOP are to be of ground, anchor pile or gravity type.

The design of the anchor piles is to comply with the recognized specifications, rules and standards.

4.6.3 The anchor and anchor shackle are to withstand a load equal to the minimum breaking load of the strongest anchor line which is to be used in conjunction with the anchor involved.

4.6.4 All anchors of MODU/FOP are to be so secured as to prevent them from shifting during transit.

4.6.5 After the unit has been positioned on station anchors are to be tested by load in order to verify their holding power.

The test load is to correspond generally to the design load on the anchor line under maximum operational conditions and is to be applied during at least 5 min.

The value of the test load is to be agreed with the Register.

4.7 QUALITY CONTROL

4.7.1 Description of the quality control arrangements in the process of manufacturing particular assemblies of the anchoring system is to be submitted to the Register. The assemblies are to be designed, manufactured and tested in accordance with recognized specifications and standards. The equipment so tested is to be durably and clearly marked by the Register and is to be delivered together with the documents showing test results.

4.8 CONTROL STATIONS

4.8.1 A manned control station is to be provided with means to indicate anchor line tensions and speed and direction of wind.

4.8.2 Reliable means of communication are to be provided to communicate between locations critical to the anchoring operation.

4.8.3 Means are to be provided at the control position of each winch to monitor anchor line tension and winch power load and to indicate the amount of anchor line paid out.

4.9 DYNAMIC POSITIONING SYSTEMS OF MODU

4.9.1 Thruster systems.

4.9.1.1 The thruster system is to be capable of producing appropriate thrust in longitudinal and transverse direction as well as turning moment to eliminate yawing and for steering on the course.

4.9.1.2 For the equipment of the dynamic positioning system which falls into classes 2 and 3, as defined in 7.5, Part XIV "Automation" of MODU/FOP Rules, the thruster system is to be so connected with the power system that the requirements of 4.9.1.1 are met even in the event that one part of the combined power system and thrusters connected thereto is failed.

4.9.1.3 The magnitude of thrust produced by the thrusters, which is used in the failure effect analysis mentioned in 7.9.4, Part XIV "Automation" of MODU/FOP Rules is to be corrected with due account of the interaction of thrusters and other factors reducing the useful thrust.

4.9.1.4 Failure of the thruster system including pitch, azimuth and speed control system is not to cause the thruster to rotate or being put on the uncontrolled maximum pitch and speed.

4.9.1.5 The calculative methods for determination of thrust and turning moment to eliminate yawing and for steering on the course are to be submitted to the Register.

4.9.1.6 The thrusters used as the sole means of dynamic positioning are to provide the level of safety equivalent to that provided by anchoring systems, to the satisfaction of the Register.

5 MOORING AND BOARDING ARRANGEMENTS

5.1 The FOP the operation of which involves the use of contact mooring method for the support vessels is to be provided with mooring and boarding arrangements to ensure approach of ships and embarkation/disembarkation of people.

5.2 The Register is to be provided with drawings and documentation of the mooring and boarding arrangements which show their location and containing detailed description of the arrangements.

5.3 In calculation of the mooring and boarding arrangements consideration is to be given to the loads due to:

.1 tied up ships swinging foul of the mooring arrangements under the action of wind, waves, current and ice (if any);

.2 a ship swinging foul when approaching the mooring arrangement;

.3 mooring line tension when the ship is subjected to wind and current action.

5.4 Account is to be taken of the provision of shielding barriers on the windward side of the tied up ship if this can result in significant reduction of the wind loads on the ship.

5.5 Mooring and boarding arrangements are to be located on at least two sides of the platform and are to rise:

by at least 1,5 m above the highest annual sea level;

by at least 1 m above the ice cover level;

by at least 0,5 m above the design wave crests when people stay on the platforms where arrangements are located.

In some cases, if approved by the Register, mooring and boarding arrangements may be located at one side of a FOP only.

5.6 The mooring and boarding arrangements of ice-resistant FOP are to ensure approach of ships and disembarkation of people under the clean water conditions and emergency evacuation of the platform personnel under all service conditions.

5.7 Where the calculation-supported possibility of performing operations at the weather condition parameters of the open sea in the operating area of the FOP, which are inferior to those given below, is not provided approach, mooring, stay of ships, cargo handling operations therefrom, transfer of people are to be assured under the following conditions:

wind speed: 8 to 10 m/s;
wave height: 0,75 to 1,25 m (force 3);
current speed: 0,6 knots.

5.8 The mooring and boarding arrangements are to provide safe conditions for making fast ships with displacement of 2500 t and over at the approach speed up to 1 knot and to withstand appropriate loads produced by ships swinging foul without damage to their particular structural elements.

In each particular case therewith the maximum displacement of the ship is to be specified in drawings, the mooring and boarding arrangements are designed for under the conditions stated in 5.7.

5.9 On the ice-resistant FOP, action of ice on the mooring and boarding arrangements when in inoperable condition is to be precluded. In each particular case therewith the maximum displacement of the ship is to be specified in drawings, the mooring and boarding arrangements are designed for under the conditions stated in 5.7.

5.10 The mooring and boarding arrangements are to be provided with systems to monitor the ship stay conditions and with means to prevent damage to ship hull due to accidental overloading.

5.11 Illumination of the places of embarkation/disembarkation at dark is to be at least 30 lux.

5.12 If necessary, mooring and boarding arrangements may be provided with mooring and fendering equipment to ensure support vessels staying. In case of contactless mooring of ships, FOP may be provided only with mooring equipment to attach cables.

5.13 Characteristics and complete set of the mooring and fendering equipment depend on the mooring method (contact, contactless, alongside, by stern), mass and overall dimensions and characteristics of mooring equipment on design ships.

Generally, it is recommended to equip FOP with a set of arrangements for hoisting and securing of mooring cables of ships: heaving lines, line-throwing appliances, mooring hawses, fairleads, bollards or bitts, self-releasing hooks, machinery (winches, capstans).

The composition and design of fendering equipment of MODU/FOP are subject to special consideration by the Register in each particular case.

5.1.14 Mooring and fendering equipment is to be designed on the basis of special calculations of interaction of ships during approach, stay and reloading from MODU/FOP:

When selecting the components of the equipment, it is recommended to:

.1 use slowly restorable shock-absorbers of high power capacity with low rigidity parameter and low friction coefficients;

.2 include safety devices ("weak link") to prevent damage to the mooring or fendering equipment as a whole;

.3 specify dimensions and arrangement of fendering equipment so that minimum loads are transferred to the hulls of ships and MODU/FOP;

.4 whenever possible, bring each mooring cable on a separate winch;

.5 ensure reasonable lengths and inclination angles for each mooring cable;

.6 provide for the possibility and ease of repairing the equipment;

.7 assume design loads on the mooring equipment items and components that are consistent with the strength of the mooring ropes of the largest design ship;

.8 use, where possible, the same components (machinery, hawses, stoppers, holders) in anchor, mooring and towing arrangements.

5.15 The mooring and boarding arrangements fitted in MODU on designer's discretion are to meet the requirements of this Section.

6 TOWING ARRANGEMENT

6.1 GENERAL

6.1.1 Each MODU/FOP is to be provided with towing arrangement. Generally, the towing arrangement of MODU/FOP is to include tow line lengths permanently secured to the hull, to which the ropes of the towing ships are connected, gear (equipment) for securing, release and hoisting of tow lines , and is also to be provided, if necessary, with tow ropes. On agreement with the Register, tow ropes may be stored on the tug and not be included into the outfit of MODU/FOP. In case of prolonged transit under severe natural conditions, it is recommended to provide a spare set of the tow rope and tow line length secured to the hull.

6.1.2 The number, composition and characteristics of the towing arrangement components depend basically on the towing resistance of MODU/FOP and pull performance of the towing ships. As a rule, the towing resistance and sufficiency of the towing pulls are to be supported by special calculations allowing for the actual conditions and specific features of the transit route. The calculations are to take into account the requirements and criteria specified in Part XVI "Marine Operations" of MODU/FOP Rules.

6.1.3 Strength of various components of towing arrangements is to correspond to that of the design tow rope selected and meet the requirements of 5.3, Part III "Equipment, Arrangements and Outfit" of Rules for the Classification and Construction of Sea-Going Ships.

6.2 TOW LINE

6.2.1 For towage with the use of a single tow tug, each non-self-propelled MODU is to be provided with tow lines while the FOP/FOP modules are to be towed with the use of tow lines according to the requirements of 5.2.2, Part III "Equipment, Arrangements and Outfit" of Rules for the Classification and Construction of Sea-Going Ships.

The breaking strength F_{br}, in N, of the tow line is to be determined from the model tests and is not to be less than the greater value determined by the formulae:

$$F_{br} = 716 S_s v^{2,6}; \qquad (6.2.1\text{-}1)$$

$$F_{br} = \begin{cases} 4P_t, & P_t < 25000; \\ 2{,}2P_t, & P_t < 100000 \end{cases} \qquad (6.2.1\text{-}2)$$

where S_s = area of the head resistance of the submerged part of MODU, FOP/FOP modules, in m^2;
v = towing speed specified in the certificates, in kn;
P_t = rated towing pull at the hook, in N;
2,2; 4 = proportionality factors (safety factors).

In the Formula (6.2.1-2), for the intermediate values of the rated towing pull, the proportionality factor (safety factor) is to be determined by linear interpolation.

6.2.2 The length of the towing line L, in m, for the non-self-propelled MODU, FOP/FOP modules is to be determined by the formula (but not less than 700 m):

$$L = 350 + 0{,}045 N_e \qquad (6.2.2)$$

where N_e = equipment number (see 3.2.1).

On agreement with the Register and if there are appropriate grounds, the length of the tow line may be reduced (where the specific conditions of the towage route and influence of the tug engines operation on the towed objects are accounted for and where shock-absorbing inserts are available, etc.).

6.2.3 For self-propelled MODU the characteristics of the tow line are to be taken from Table 3.1.3-1, Part III "Equipment, Arrangements and Outfit" of Rules for the Classification and Construction of Sea-Going Ships according to the equipment number determined in compliance with 3.2 of MODU/FOP Rules.

6.2.4 On agreement with the Register, MODU may be not provided with a tow line if:

.1 the MODU is towed by a tug provided with a tow line with characteristics not lower than those specified in 6.2.1 to 6.2.3;

.2 the MODU carries a sufficient number of arrangements of adequate strength for securing the tow line taken in from the tug.

6.3 CHAIN CABLES

6.3.1 When chain cables are used as a part of the tow line, the breaking strength of these chain cables is not to be less than the design breaking strength of the tow rope.

Chain cables are to be included into the total length of the tow line.

6.4 TOWAGE WITH THE USE OF SEVERAL TUGS

6.4.1 When the MODU, FOP/FOP modules are being towed by several tugs, the breaking strength F', in N, of each tow line is not to be less than that determined by the formula

$$F' = K_4 F_{br}/n \qquad (6.4.1)$$

where K_4 = the coefficient equal to 1,15 when towed by two tugs and to 1,3 when towed by three and more tugs;
n = number of tow lines;
F_{br} = the design breaking strength when towed by one tug, in N.

6.4.2 The total length of the tow line L_t, in m, for each tug is to not to be less than:

$$L_t = 2000 P_t / F_{br} \qquad (6.4.2)$$

where P_t = towing pull, in N;
F_{br} = minimum breaking strength of the tow line, in N.

6.5 SPECIAL ARRANGEMENTS

6.5.1 MODU/FOP is to be provided with arrangements for passing the tow line to the tug or towing vessel and for taking in of the line.

Where during the transit escort tugs are used, additional towing arrangements are to be provided. The strength of the connecting devices of these arrangements is to be 1,3 times higher than the minimum breaking strength of the relevant tow line.

Where towing and handling operations are to be carried out, the towing arrangement is to include mooring (bumpering) and special boarding facilities.

During the period of towing the special arrangements are to provide access of the personnel to MODU/FOP.

6.5.2 If synthetic fibre rope inserts are used in tow lines, the total breaking strength of the insert is to be not less than 2,3 times the minimum breaking strength of the tow line when the towing pull is less than 500 kN and not less than 1,5 times the minimum breaking strength of the tow line when the towing pull is more than 1000 kN.

For tugs with the towing pull within the range from 500 up to 1000 kN, the safety factor is to be determined by linear interpolation.

7 SIGNAL MASTS

7.1 GENERAL

7.1.1 The signal masts are to meet the requirements of Section 6, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships; the angles of heel and trim are to be taken considering the maximum parameters of motions for the MODU concerned.

The signal masts of FOP/FOP modules are subject to special consideration by the Register in each particular case.

7.1.2 Installation of signal means is to comply with the requirements of Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships and Part II "Signal Means" of the Rules for the Equipment of MODU/FOP.

8 OPENINGS IN HULL, SUPERSTRUCTURES AND DECKHOUSES AND THEIR CLOSING APPLIANCES

8.1 GENERAL

8.1.1 The requirements of this Section apply to arrangement and closing appliances of openings located above the margin line of a MODU and FOP/FOP module while afloat according to 1.1, Part V "Subdivision" of MODU/FOP Rules.

Openings located below the margin line and their closing appliances are subject to special consideration by the Register.

8.1.2 Openings in hull, superstructures and deckhouses of the MODU to which a minimum freeboard has been assigned, and their closing appliances are to be in full compliance with the requirements specified for ships of unrestricted service in Section 7, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships and with the expressly specified requirements of MODU/FOP Rules.

8.1.3 Surfaces adjacent to rotary table are to have, as far as possible, no openings through which gas or water could penetrate into hull structures. All such openings which are unavoidable are to be provided with fast-acting closing appliances.

8.2 COAMINGS

8.2.1 The coaming height of openings for doors, companion hatches, skylights, ventilating trunks, ventilator cowls, cargo hatches in exposed areas as well as closing appliances of these openings is to be determined with regard to the requirements for intact and damage stability and according to the position of the openings specified in 7.1.4, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships.

8.2.2 The Register may relax the requirements for the coaming height proceeding from:

.1 the value of the freeboard assigned provided that it is much greater than that required by Load Line Rules for Sea-Going Ships;

.2 the purpose of the spaces to which these openings lead;

.3 the dimensions, location, strength and watertight integrity of the spaces.

8.3 OPENINGS IN WATERTIGHT SUBDIVISION BULKHEADS AND THEIR CLOSING APPLIANCES

8.3.1 Openings in watertight subdivision bulkheads and their closing appliances in MODU/FOP are to meet the requirements of 7.12, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships and the expressly specified requirements of MODU/FOP Rules.

8.3.2 The requirements of the present Section cover the MODU/FOP to which the requirements of Part V "Subdivision" of MODU/FOP Rules are applicable.

8.3.3 Doors and manholes in watertight subdivision bulkheads.

8.3.3.1 Doors are to be remotely operated from the central control station on the deck which is above the damage waterline after flooding and are also to be operable locally from each side of the bulkhead. Indicators are to be provided at the control station to show whether the doors are open or closed.

8.3.3.2 The requirements for remote control may be dispensed with for those doors or hatch covers which are normally closed while the MODU/FOP is afloat, provided that an indication system is arranged to show to the personnel both locally and at the central control station, whether the doors or hatch covers are open or closed.

A notice plate is to be affixed to each of these doors or hatch covers to bear a warning that they must be closed while the MODU/FOP is afloat.

8.4 HATCH COVERS

8.4.1 Covers of companion hatches are to be watertight and fitted with quick action devices for securing and opening and also with position indicators.

A notice plate is to be provided to show the position of the cover when the MODU/FOP is in the operating or transit condition.

8.5 MANHOLES

8.5.1 The design of manholes for pontoons of semi-submersible or submersible MODU is subject to special consideration by the Register.

9 ARRANGEMENT AND EQUIPMENT OF SPACES

9.1 GENERAL

9.1.1 The arrangement and equipment of spaces are to comply with the requirements of Section 8, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships and the expressly specified requirements of MODU/FOP Rules.

9.1.2 The MODU/FOP are covered by the requirements of the Rules for the Classification and Construction of Sea-Going Ships applicable to special purpose ships.

9.1.3 Arrangement of low location lighting (LLL) at the escape routes of MODU/FOP with a special crew of 200 and less persons is subject to special consideration by the Register.

9.2 EXITS, DOORS, CORRIDORS, STAIRWAYS AND VERTICAL LADDERS

9.2.1 At least two separate escape routes are to be provided from each deck having spaces which are likely to be regularly manned or in which personnel is accommodated, to the open decks and places of embarkation into lifeboats and liferafts.

9.2.2 As an exception, the Register may permit only one means of escape, due regard being paid to the nature and location of spaces and the number of persons who normally might be accommodated or employed there.

9.2.3 Exits from spaces and structures leading to the area where toxic or explosive gases are likely to release are not permitted.

9.2.4 A vertical ladder may be permitted by the Register to be used as a means of escape when the installation of a stairway is proved to be impracticable.

9.2.5 All corridors and passageways are to be readily accessible and unobstructed.

Dead-end corridors exceeding 7 m in length are not permitted.

9.2.6 The industrial spaces of MODU/FOP are to be provided with exits located on opposite sides. The exits are to be provided with doors which open outside.

9.3 GUARD RAILS, BULWARK

9.3.1 Any exposed areas and companionway openings in the decks are to be provided with guard rails, bulwark or other arrangements complying with the requirements of 8.6, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships.

10 ARRANGEMENT FOR LIFTING AND LOWERING COLUMNS OF SUBMERSIBLE SEA WATER PUMPS

10.1 GENERAL

10.1.1 The requirements of the present Section apply to assemblies and components of the arrangement intended for lifting and lowering the columns of submersible sea water pumps of self-elevating MODU, except for the assemblies and components the requirements for which are specified in Part I "Classification", Part II "Hull", Part VI "Fire Protection" and Part VII "Machinery Installations and Machinery" of MODU/FOP Rules.

10.2 SPECIAL REQUIREMENTS

10.2.1 Each submersible sea water pump is to be installed on its own column and is to be independently driven.

10.2.2 The design of the well is to allow for free movement of the column with the pump installed at the maximum permissible heel and trim of the MODU and at nominal parameters of the wind and waves.

10.2.3 The arrangement is to comprise guides which allow for vertical movement of the column and prevent its spontaneous rotation around its own axis.

10.2.4 Provision is to be made for stoppers intended for fixing effectively the column in the required (top, down, intermediate) position and for relieving the stresses in driving machinery induced by environmental and functional loads under operating conditions of the MODU as defined in Part II "Hull" of MODU/FOP Rules.

10.2.5 Assemblies and components of the arrangement for lifting and lowering submersible sea water pumps are to be checked for strength under the action of static functional loads.

10.2.6 The column structure is to be calculated for strength under the action of environmental loads due to maximum permissible waves and wind stated in the Operating Manual for the MODU considered and of loads due to current in the prescribed area of operation and transit.

10.2.7 When a cable drive is chosen, its design and strength is to meet the requirements of the Rules for the Cargo Handling Gear of Sea-Going Ships.

10.2.8 The design of the arrangement is to allow for lowering of the column and connection of the submersible pump to the system during not more than 15 min.

11 JACKING SYSTEM FOR THE HULL OF SELF-ELEVATING MODU

11.1 GENERAL

11.1.1 The requirements of the present Section apply to jacking system intended for elevation and lowering of the platforms and legs of MODU.

This system is also to comply with the requirements specified in Part I "Classification", Part II "Hull", Part VI "Fire Protection" and Part VII "Machinery Installations and Machinery" of MODU/FOP Rules.

11.1.2 Each leg is to be served by an independent gear.

11.2 SPECIAL REQUIREMENTS

11.2.1 The jacking system is to be so designed as to preclude spontaneous relative motion of the legs and platforms of MODU and retain efficiently the elevated platforms or legs in required position with the drive being inoperative.

For hydraulic jacks provision is to be made for an arrangement to allow for relieving of the hydraulic system when in non-operative mode, except for the jacks operated by hydraulic cylinders with pilot operated check valves available.

11.2.2 Fixation of the jacks on the substructure and joining of the components of the system are to be made so that warping due to manufacturing and mounting defects could not have an adverse effect on the operation of the system.

11.2.3 The components of the system are to be checked for strength having regard to the loads specified in Section 2, Part II "Hull" of MODU/FOP Rules.

11.2.4 The allowable stresses are determined in accordance with the requirements of Part II "Hull" of MODU/FOP Rules.

11.2.5 The jacking system is to allow for self-checking or is to be provided with a device to do this before the MODU platform begins to be elevated or lowered.

11.2.6 The jacking system is to operate reliably at the maximum permissible heel and trim which are specified in the Operating Manual for the MODU concerned.

11.2.7 The jacking system is to be so designed as to exclude the possibility of simultaneous disengagement of all the catches toothed into racks of the legs.

11.2.8 The jacking system is to allow for disconnection of any of the main cylinders in case of failure of the cylinder or its piping.

In this case, the system is to permit moving of the platform and legs of the MODU until the safe position is reached.

11.2.9 In order to keep the column in the required position, each jacking system is to be provided, if necessary, (at the designer's discretion) with relieving and fixing devices capable of taking up all the loads acting on the legs under particular operating conditions and of transmitting the loads to the hull of the MODU.

11.2.10 The fixing devices (if any) are to be designed so that fast releasing of the legs could be possible at any operational warping of the legs with respect to the hull.

12 EMERGENCY OUTFIT

12.1 GENERAL

12.1.1 The emergency outfit of MODU is to be in full compliance with the requirements of Section 9, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships and the expressly specified requirements of MODU/FOP Rules.

The emergency outfit items for the FOP are subject to special consideration by the Register in each case.

12.1.2 MODUs which are defined in 1.2.1 to 1.2.4, 1.2.5.3, 1.2.6 and 1.2.16, Part I "Classification" of MODU/FOP Rules are to be provided with the emergency outfit according to items 4, 5, 6, 8, 10, 12, 13, 15 to 32, 34 to 40 of Table 9.2.1, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships as specified for ships from 70 up to and including 150 m in length.

PART IV. STABILITY

1 GENERAL

1.1. APPLICATION

1.1.1 The requrements of the present Part of MODU/FOP Rules apply to:

.1 newly built MODU/FOP hereinafter referred to as "units", if in floating condition and if their hull form cannot be regarded as conventional for ships and barges;

.2 structural members of MODU/FOP hereinafter referred to as "units", if in floating condition;

.3 sea-going ships hereinafter referred to as "units", whose position-keeping systems which ensure functioning of a ship for its designed purpose cannot be regarded as conventional anchoring systems complying with the requirements of Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships;

.4 existing MODU/FOP and above-mentioned ships hereinafter referred to as "units", if as the result of repair and/or conversion their stability is impaired;

.5 MODU/FOP and/or above-mentioned ships hereinafter referred to as "units" in service as far as it is reasonable and practicable.

1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology are given in Part I "Classification" of MODU/FOP Rules.

For the purpose of the present Part the following definitions have been adopted.

1.2.1 General definitions.

Floating structure is a unit which at all stages of its life cycle is in a floating condition and, while in service, may be exposed to extreme environmental conditions.

Fixed structure is a unit which at all times is supported by seabed, while in service, and for which a floating condition may be regarded as a short-time condition associated with its construction, outfitting and/or transportation periods, for example, FOP.

It is assumed, that for the fixed structures, while afloat, the possibility of exposure to extreme environmental conditions is obviously eliminated.

For the purpose of the present Part of MODU/FOP Rules, among the floating structures are:

semi-submersible floating structure without excessive buoyancy positioned with the use of an anchor-mooring system and/or thrusters (dynamic positioning system);

semi-submersible floating structure with excessive buoyancy and pretensioned anchor-mooring system;

self-elevating unit is a unit with movable legs resting on seabed, for which the floating condition may be regarded as short-time condition associated with outfitting and transit periods.

The floating structure and fixed structure incorporate generally the following structural members:

hull is a watertight structure which ensures bouyancy and stability of a unit. The hull may be divided into one, two or more lower hulls (pontoons), as a rule, submersible, and upper hull which is usually above water;

upper deck is a watertight structure forming the top of the hull, from which the freeboard is measured;

upper structure is structures on the upper deck which constitute superstructures and deckhouses used to accommodate personnel, equipment, systems and arrangements essential to functioning of the unit for its designed purpose. The upper structure consists generally of modules — of functionally independent structures such as power, industrial, accommodation, etc;

supporting assembly is a carrying structure of the unit to provide support and resistance of the unit to environmental effects when it is placed on the seabed. The lower hull (hulls) may serve as a supporting assembly;

module is, as a rule, a structure of the hull, supporting assembly, upper structure and a part thereof which constitutes a transport unit for which the floating condition may be regarded as a short-time condition associated with their outfitting and/or transportation periods.

It is assumed, that for the module the possibility of exposure to extreme environmental conditions is obviously eliminated;

transport unit is a unit moved in the floating condition by inland waterways and/or by sea;

unit is a ship, MODU, FOP, other structures, a module and/or any their components covered by the requirements of the present Part;

b u o y a n c y / s t a b i l i t y p o n t o o n is a watertight structure installed temporarily on the unit to ensure its buoyancy and/or stability.

O p e n i n g s c o n s i d e r e d t o b e o p e n are openings in the weather decks, hull sides, columns and bulkheads of superstructures and deckhouses, the closing appliances of which do not comply with the requirements of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of MODU/FOP Rules as far as their strength, weathertightness and efficiency are concerned. Small openings such as discharges of ship systems and pipes which have actually no effect on stability in dynamical heeling are not considered to be open.

T r a n s i t s t o r e s are fuel, fresh water, lubricating oil, provisions, consumable stores (ship's stores) intended for use during transit and minimum amount of drilling stores necessary for commencement of the operations.

L i m i t i n g a n g l e o f s t a t i c a l h e e l u n d e r t h e e f f e c t o f t h e h e e l i n g m o m e n t is the lesser of the down-flooding angle φ_f and the angle φ_2 corresponding to the second intercept of the righting moment curve and the heeling moment curve.

1.2.2 Design modes.

L i f e c y c l e o f M O D U / F O P is all stages of construction, operation and liquidation of a unit.

C o n s t r u c t i o n is a condition wherein building or outfitting work afloat is performed (e.g. joining of modules, erection of the upper structure in the Builder's basin).

P r e p a r a t i o n is a condition wherein work is performed to change the unit from one state to another (e.g. partial dismounting of structures and equipment to improve the stability characteristics).

M a r i n e o p e r a t i o n is actions to be performed in inland waterways and at sea, which are necessary for construction, transportation and placing of the unit on the operating site in accordance with the Marine Operations Manual.

O p e r a t i o n is a condition wherein work is performed in accordance with the MODU/FOP purpose and with the Operating Manual.

L i q u i d a t i o n is a condition wherein the MODU/FOP structural integrity is intentionally broken (the unit is removed from the operating site) in order to terminate the operation.

P r e d e t e r m i n e d c o m b i n a t i o n o f e n v i r o n m e n t a l e f f e c t s is a combination of environmental loadings established for the unit for the given design mode in the prescribed operating area or during marine operation.

1.2.3 Design conditions.

S u r v i v a l c o n d i t i o n is an ultimate condition wherein in case of severe (design) storm or severe ice conditions the unit is to withstand environmental loadings corresponding to such condition.

The stability criteria in the survival condition are to be, whenever possible, met by means of appropriate technical solutions incorporated in the design. The above criteria may be also met through:

interruption of an operation (e.g. bringing the unit to an anchor during transit, raising to the original position or grounding) if this improves the safety of the unit and if interruption of an operation may be be effected within not more than three hours;

implementation of protective arrangements without interruption of an operation or coincidentally therewith (e.g. by means of ballasting).

N o r m a l c o n d i t i o n is a condition wherein work is performed in accordance with the purpose of the unit and with the Operating Manual.

T e m p o r a r y c o n d i t i o n is a condition wherein marine operations are performed in accor-dance with the Marine Operations Manual, including:

towage;

afloat joining of the units;

launching, including launching from a barge;

change to vertical position;

floating of the unit on the underlaying structures;

grounding, including positioning, submergence, pre-loading of legs and righting up;

bringing off the ground, including raising;

During preparation and carrying out marine operations consideration is to be given to the draught, inclination, stability, vertical clearance, freeboard, ballasting of all ships and units involved in the operations, in particular, barges with or without the unit to be launched, as well as the system of facilities to provide floating-on of the unit (barges, support assemblies, pontoons, crane and other vessels) in accordance with the procedures approved by the Register.

T r a n s i t c o n d i t i o n is a condition wherein a unit may be moved from one geographical location to another.

1.3 SCOPE OF SUPERVISION

1.3.1 General provisions pertaining to the procedure of classification, conducting and scope of surveys, as well as the aggregative list of the technical design documentation, to be submitted to the Register for consideration and approval are contained in Part I "Classification" of MODU/FOP Rules.

1.3.2 For every unit meeting the requirements of the present Part, the Register may carry out the following:

.1 prior to commencement of the unit's construction — consideration and approval of technical documentation relating to the unit's stability;

.2 during the unit's construction, conversion, marine operations and trials — supervision over the inclining tests and marine operations;

consideration and approval of the Inclining Test Reports, Information on Stability and Marine Operations Manual;

.3 during special surveys for the purpose of class renewal and after repair or modernization — inspections to check for changes in the lightweight condition in order to conclude whether the Information on Stability is still applicable.

1.4 GENERAL TECHNICAL REQUIREMENTS

1.4.1 Calculations.

All calculations are to be made by the methods approved by the Register. When using a computer, the methods of computation are to be approved and the programs certified by the Register. The copies of the programs are to have the authors' licenses.

1.4.2 Calculation of cross-curves of stability.

1.4.2.1 To be determined prior to the calculation of the cross-curves of stability are:

design modes and design conditions of the unit;

reasonable position of the unit's coordinate axes;

axes of inclination.

The cross-curves of stability are to be calculated for the most critical axes of inclination as regards stability. Where the position of such axes cannot be indicated without performance of an appropriate calculation, a circle stability diagram or a part thereof is to be constructed; for this purpose calculations are to be made for the condition when the unit is inclined about different axes with such a step that enables determination of the most critical axis of inclination in each design case.

An example of calculation of the most critical axes of inclination of the circle stability diagram is given in Appendix 1 to the present Part.

1.4.2.2 When calculating the cross-curves of stability, account is to be taken of all watertight volumes of the units, as well as buoyancy/stability pontoons (if installed on the unit), deck wells, trunks, compartments of air cushion skirts, with due regard for the possibility for the water to spread over the spaces and compartments at the inclinations being considered.

1.4.2.3 Superstructures, deckhouses and similar structures may be taken into account in the calculations of the cross-curves of stability provided their strength meets the requirements of Part II "Hull", and the design and means of closing of openings meet the requirements of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of MODU/FOP Rules. Openings which do not comply with the said requirements are considered to be open.

1.4.3 Arrangement of compartments.

Drawings of watertight compartments and compartments of air cushion skirts, tanks and wells are to contain data necessary to make stability calculations, including volumes and positions of the centres of gravity for tanks filled with liquid cargoes and values of corrections for the effect of free surfaces of liquids on stability.

1.4.4 Deck plans.

Deck plans included in the design documentation are to contain all data necessary to determine the centres of masses of deck cargoes. Where heavy deck cargoes are likely to be relocated in the process of operation, two extreme positions of these cargoes or equipment are to be indicated in the deck plans.

1.4.5 Arrangement of doors, companionways and side scuttles. Angle of flooding.

The arrangement plan of doors, companionways and side scuttles which are to be taken into account when calculating the cross-curves of stability is to include all openings in the decks, hull sides, columns, bulkheads of superstructures and deckhouses with indication of the degree of their tightness and with appropriate references to their design, as specified in Part III "Equipment, Arrangements and Outfit of MODU/FOP" of MODU/FOP Rules.

The flooding angle data, either in the form of a curve or in the tabular form are to be appended to the calculations of the cross-curves of stability.

1.4.6 Computation of free surface effect of liquids.

1.4.6.1 Tanks for each kind of liquid which according to the construction, marine operations and service conditions may simultaneously have free surfaces, as well as stabilizing tanks are to be taken into account when determining the free surface effect of liquids on stability. The heeling moment δM_φ, kN·m, due to liquid overflow is to be computed about the axis involved of the unit' s inclination to an angle φ.

Besides, account is to be taken of the water on the deck during submergence/raising, as well as in other locations from which it cannot be removed.

Considering the number of tank combinations for the individual kinds of liquids or single tanks, likely to occur, only those developing the greatest total heeling moment δM_{15} due to liquid overflow at the unit's inclination of 15° are to be selected. In all cases the correction for free surfaces is to be calculated for each tank assumed to be filled to 50 per cent of its capacity.

1.4.6.2 The tanks to be taken into account are to be chosen in compliance with the Marine Operations

Manual or Instructions on Loading and Consuming of Liquids.

The tanks complying with the following condition are to be not included in the calculation:

$$\delta M_{15} \leqslant 0{,}02 g \Delta_{min} \quad (1.4.6.2)$$

where g = gravity acceleration, m/s^2,
Δ_{min} = unit displacement corresponding to the minimum mass loading of the variants under consideration, t

Total correction δM_{15} for tanks not included in the calculation is not to exceed $0{,}05 g \Delta_{min}$. Otherwise, appropriate corrections are to be taken into account in the computation.

1.4.6.3 Operations with liquids used as ballast during marine operations (loading, discharge, transfer) are to ensure preservation of the allowable values of the metacentric height (in compliance with Section 3), draught and the unit's inclination angles.

1.4.6.4 Where sea valves are used to take in water during marine operations, provision is to be made for preserving the values of the metacentric height (in compliance with 3.1.3), draught and the unit's inclination angles.

1.4.7 Design data relating to stability checking.

1.4.7.1 The scope of the technical design documentation relating to stability to be submitted to the Register is to be agreed with the latter having regard to structural features and service conditions of the unit or content of the marine operations but is not necessarily to include the following documents to be submitted at the design stages:

.1 plan of subdivision showing all watertight structures and openings with indication of their arrangement, dimensions and types of closing appliances;

.2 lines drawing;

.3 calculation materials relating to verification of the unit's trim and stability in compliance with the requirements of the present Part, including:

mass loading calculation;

arrangement of variable cargoes, including liquid cargoes and ballast;

plan of extreme positions of cargoes and equipment which may be stowed in different positions;

calculations and diagrams of windage area, icing and snow;

calculations of righting and heeling moments (having regard to the effect of drift ice, position-keeping systems, buoyancy/stability pontoons, influence of support reaction when in contact with the seabed);

calculation of corrections for free surface effect of liquids;

calculation of motion amplitudes;

metacentric diagrams for submergence/raising operations;

Marine Operations Manual;

Ballast Water Management Plan.

1.4.7.2 Use of the floating-on method during mounting or handling of the units is to be taken into account in the calculations.

1.4.7.3 The scope of the documentation, where submitted for examination at the early stages of design work, is to be defined on agreement with the Register.

1.4.8 Requirements for the Information on Stability.

1.4.8.1 In order to assist the master of the unit in maintaining an adequate stability of the unit in service, and in order to render assistance to the control authorities, the Information on Stability approved by the Register is to be developed and issued.

The information is to contain data on the unit's stability in compliance with the requirements of the present Part.

Formal observance of the provisions contained in the Information does not relieve the Master of the responsibility for the stability of the unit.

1.4.8.2 The format of the Information and the data included may vary dependent on the type and purpose of the unit, its operating area, stability reserve.

The Information is to contain in particular the following data:

.1 particulars of the unit;

.2 stability data for typical, predetermined loading conditions in order to provide stability of the unit in its design conditions: normal, transit, survival, as well as during submergence/raising;

.3 directions on restrictions proceeding from the hydrometeorological conditions for different loading conditions in order to provide stability of the unit, including instructions on necessary actions to be taken in the preparation condition (e.g. to pass from the normal condition to the survival one, etc) and time required to perform appropriate operations;

.4 directions on ballasting in compliance with the Ballast Water Management Plan and directions on limitation of deck and other cargoes for the typical loading conditions of the unit in its design conditions: normal, survival and during submergence/raising;

.5 supporting diagrams, tables and other data to evaluate stability of the unit for any loading conditions not specified beforehand but likely to occur in service, as well as directions on use of such data with appropriate examples;

.6 recommendations on maintaining stability of the unit;

.7 data on recommended sources of hydrometeorological information.

When compiling the Information, the provisions of the Appendix I to Part IV "Stability" of the Rules for the Classification and Construction of Sea-Going Ships are to be followed considering structural, operational and other peculiarities of a certain unit.

1.4.8.3 The Information is to be based on the unit's inclining test data. Where serial units are constructed at the same shipyard, the Information prepared for the first unit may be used for subsequent units provided the requirements of 1.5.2 are met.

1.4.8.4 The Information on Stability may either be prepared as a separate document or as a part of the Operating Manual of the unit.

1.4.9 Requirements for the Marine Operations Manual.

1.4.9.1 For each unit afloat, in order to ensure its safety during marine operations, Marine Operation Manual approved by the Register is to be prepared and brought to the notice of the Deliverer of the unit (performer of the operation).The Manual is to contain in particular the following data:

.1 general description of the unit;

.2 stability data for all stages of construction and outfitting afloat specified by the design as well as for operations in their designed (operational) sequence;

.3 directions on restrictions proceeding from the hydrometeorological conditions for different operation stages;

.4 directions on the procedures of ballasting, mounting (dismounting), relocation of cargoes in accordance with scheme and practice of performing each operation;

.5 recommendations for maintaining stability of the unit and other directions on safe performance of the operation;

.6 data on recommended sources of hydrometeorological information.

1.4.9.2 The Manual is to contain indication that satisfaction of the requirements of the present Part does not relieve the deliverer of the unit of the responsibility for the stability of the unit during marine operations.

1.4.9.3 The Manual is to be based on the unit's inclining test data. Where serial units are constructed at the same shipyard, the Manual prepared for the first unit may be used for subsequent units provided the requirements of 1.5.2 are met.

1.4.10 Requirements for the Ballast Water Management Plan.

The format of the Plan and information included may vary dependent on the unit type, purpose and operating area.

The Plan is to contain, in particular:

.1 detailed instructions as regards operation of pumps, ballast system, preparation of tanks and air pipes for ballasting operations;

.2 instructions for prevention of over- and underpressurization of tanks;

.3 information on free surface effect of liquids on stability and tankage in tanks that may be slack in any one time;

.4 information on weather conditions admissible for ballast exchange;

.5 weather routing in areas affected by cyclones, typhoons and hurricans, or heavy icing conditions;

.6 instructions on maintenance of adequate intact stability during liquid ballast operations in accordance with an approved Information on Stability;

.7 accepted values of minimum/maximum draughts;

.8 instructions for documented record of ballasting operations;

.9 instructions for contingency procedures for situations which may affect the water ballast exchange (including worsening of weather conditions, pump failure, de-energization of the unit, etc);

.10 information on time necessary to perform ballasting operations and sequence thereof;

.11 instructions for monitoring the amount of ballast water;

.12 list of manholes which may be left opened during ballasting with a notification that they are to be closed after completion of ballasting;

.13 instructions for ballasting under low temperatures;

.14 list of conditions and circumstances which do not allow ballasting and deballasting.

1.5 INCLINING TEST

1.5.1 An inclining test is to be required for newly built units referred to in 1.1.1.1, 1.1.1.2 and 1.1.1.3; existing units referred to in 1.1.1.4 and 1.1.1.5 and buoyancy/stability pontoons.

1.5.2 On agreement with the Register the following units may be exempted from the inclining test:

.1 units which are convincingly claimed to have adequate stability under all loading conditions specified by the present Part for the unit afloat. Such claim is to be based on a comparison with similar units by the architectonic-constructive features, principal dimensions, general arrangement and mass loading proceeding from the experience in designing, building and operating thereof;

.2 units where an increase of the design centre of gravity height by 20 per cent will not result in violation of the requirements of the present Part (not applicable to ships engaged in international voyages);

.3 very big units which cannot be inclined; such a decision is to be based on comparison with similar units, proceeding from the experience in designing, building and operating thereof.

1.5.3 Where serial units are built at the same shipyard, the inclining test is to be required for:

.1 the first unit of the series;

.2 a unit whose light mass confirmed by the weight and dimensional monitoring means and/or by "reballasting" differs from that of the first unit by more than 2 per cent ("reballasting" means determination of trim, displacement and centre of buoyancy coordinates);

.3 unit whose centre of gravity height in light condition increases by more than $0{,}05\Delta_1 h/\Delta_0$ (where h = the least value of the corrected initial metacentric height at displacement Δ_1 of the unit involved during inclination, t; Δ_0 = displacement of the first unit during inclination, t) as compared with that of the first unit;

.4 unit in which changes in the displacement and centre of gravity height are not more than those referred to above but the requirements of the present Part are not met.

Based on the differences referred to in 1.5.3.2 to 1.5.3.4, such series-built unit is considered to be the first unit of a new series as regards stability, and the inclining test procedure of subsequent units is to comply with that mentioned above.

The Information on Stability of a series-built unit is to take account of the correction for the difference in mass and in centre of gravity position as compared with the unit which has been subjected to the inclining test.

1.5.4 Where the inclining test results of a unit show that its actual displacement and/or centre of gravity height exceed the design value to the extent that involves non-fulfillment of the requirements of the present Part, a unit's Inspection Record containing exhaustive explanation of the reasons of such differences is to be attached to the Inclining Test Report.

The Register may require the repeated inclining test of the unit.

1.5.5 Mass loading of a unit to be inclined is to be as far as practicable close to the loadings considered in the specific design conditions from among those referred to in 1.2.3.

Where the loading of the units in operating condition is more critical in respect of fulfillment of the stability requirements than during performance of marine operations, such units are to be inclined at mass loading as far as possible close to the critical one in conformity with the Information on Stability.

1.5.6 The metacentric height of the unit in the process of inclining test is to be such as to ensure safety of the inclining test and in any event it is to be not less than 0,05 the centre of gravity height.

For the purpose of meeting this requirement and ensuring favourable trim of the unit necessary ballast is to be taken. When water ballast is taken, the tanks containing such ballast are to be carefully pressed up and their volumes and centres of gravity coordinates determined accurately.

1.5.7 For column-stabilized units, a displacement survey is to be conducted at intervals not exceeding five years. Where the displacement survey indicates a change from the design displacement in excess of 2 per cent, an inclining test is to be conducted.

1.5.8 An inclining test is to be carried out in the presence of a Surveyor to the Register in compliance with the Guidance for the Conduct of an Inclining Test for a particular unit approved by the Register. This Guidance is to be prepared on the basis of model Guidance given in Appendix 2 to the present Part.

1.5.9 The results of the inclining test, or deadweight survey and subsequent inclining test, if conducted in conformity with 1.5.4, are to be indicated in the Information on Stability. A record of all changes in structure, machinery, equipment and outfitt that affect the light displacement of the unit are to be maintained every day in the log book.

1.5.10 Solid and water ballast is to be used as a heeling ballast during the inclining test. The heeling ballast may be moved from side to side with the help of the unit's own cargo cranes as well as shore-based cranes.

1.5.11 The total amount of heeling ballast is to be determined proceeding from the condition that when all heeling ballast are positioned on one side in their allocated places, the unit would be inclined to 1 — 5°, depending on its salient features, and that the waterline form is not to be changed and the hull counters and undercuts do not emerge, as this takes place.

The initial heel of the unit is not generally to exceed 0,3°.

In the Guidance for the Conduct of an Inclining Test to be prepared for a specific unit the said inclination angles may be finalized depending on the actual conditions wherein the inclining test is conducted.

1.5.12 When the unit is inclined by liquid ballast, it is essential to know the shape, volumes, volume centres of gravity of the tanks used for the heeling ballast, given in their calibration tables having regard to structure and equipment of these tanks. Preference is to be given to the side, symmetric about the inclination axis, sufficiently deep and narrow tanks, regular in shape, wherever possible. Compliance of the tanks with their drawings is to be verified on the spot.

Tanks containing heeling water ballast are to be efficiently pressed up or left slack within the wall-sided portion.

1.5.13 The Inclining Test Report, drawings and calculations associated with processing of the test data, as well as the unit's mass loading calculations are to be submitted to the Register.

2 GENERAL REQUIREMENTS FOR STABILITY

2.1 POSITION-KEEPING SYSTEM. SUPPORT ON SEABED

2.1.1 The effect of the position-keeping system (passive system: anchoring, mooring or active system: dynamic positioning, combined) is to be taken into account:

.1 in normal condition;

.2 in survival condition, if this results in the worse, as regards stability, estimations of criteria (e.g in the event of failure of one, several or all positioning restraints) and if no provision is technically made for relieving the unit of the position-keeping system influence in a time period not more than three hours;

.3 in temporary condition, if the use of a position-keeping system is stipulated by the Marine Operations Manual.

2.1.2 The position-keeping system is to be designed for operation under effect of floating ice, if this is specified by the Operating Manual and the ice forces taken up by the position-keeping system are to be accounted for in the stability calculations.

2.1.3 Procedure used to account for the effect of the position-keeping system on the stability is to be approved by the Register, and the stability calculation program is to have the Register Certificate.

2.1.4 If during an operation under consideration, the unit's touching of the seabed or support thereon is stipulated by the design or may be feasible technically, the support reaction is to be properly accounted for in the unit's trim and stability calculations in accordance with the procedures approved by the Register.

2.2 LOADING CONDITIONS

2.2.1 Stability is to be generally checked for the whole range of possible loading conditions in all design conditions of the unit. Account is to be taken of the most unfavourable position of the cargoes and equipment to be moved.

When passing from the normal or temporary condition to the survival one, the procedures recommended and the approximate length of time required for passing from one condition to another are to be indicated in the Information on Stability and in the Marine Operations Manual.

Account is to be also taken of the loading conditions based on the considerations applied to the:

accepted (permissible) design loads on the structural members of the unit's hull, proceeding from the conditions of the maximum environmental loading action, as specified in Part II "Hull" of MODU/FOP Rules;

environmental loads arising due to significant change in the unit's trim as a result of flooding of a compartment or a group of compartments due to a damage;

provision of a necessary vertical clearance and immersion of the unit when transported and when operations are performed in various design modes and conditions.

2.2.2 The equipment and cargoes and consumables taken on the unit are to be so arranged that the survival condition can be achieved without the relocation or removal of solid consumables, equipment or other variable loads.

The Register may permit relocation or removal of solid consumables and equipment on a unit when going to the survival condition, provided:

.1 stability requirements stated in Section 3 are met;

.2 the unit is operated in the area where weather conditions do not become so severe as specified in the Information on Stability;

.3 mass loads are handled within a short period of time that is well within the bounds of a favourable weather forecast.

The permissible operating areas, weather conditions and loading conditions are to be identified in the Information on Stability.

2.2.3 Included in the loading conditions chosen may be such conditions which correspond to:

.1 the least stability coefficient $g\Delta h_0$, (where g is gravity acceleration, in m/s^2; Δ is displacement, in t; h_0 is metacentric height during inclination about the most unfavourable axis, in m);

.2 the least elevation of the openings above the waterline, through which water may enter the compartments the flooding of which will produce change in the ordinates of the righting moment curve by more than 5 per cent;

.3 the least immersion of the openings below the waterline, through which air may be released from the compartments with air pockets, if such release will produce change in the ordinates of the righting moment curve by more than 5 per cent;

.4 the worst values of the intact stability criteria.

2.2.4 In calculating the trim and stability of a unit during construction, account is to be taken of the access holes through which water may enter the watertight compartments.

2.2.5 Marine operations are to be considered by stages and the most dangerous loading conditions are to be determined for each stage.

2.2.6 During the unit movement, transportation and launching operations, consideration is to be given to the trim and stability of supply vessels involved in the operation with due regard for the loads acting from the supported unit side.

2.2.7 Where marine operation or use of a unit is made in the winter seasonal area, consideration is to be given to the loading condition with ice and snow accretion as specified in 2.5.5.

2.3 RIGHTING MOMENT CURVES

2.3.1 Curves of righting moments M_φ, in kN·m, of a unit are to be calculated and plotted:

.1 covering all loading conditions under consideration, when the unit is inclined about the most unfavourable axis as regards stability;

.2 taking into account the free surface effect of liquids (cargoes, consumables, ballast, liquid in the stabilizing tanks, etc) in conformity with the Ballast Water Management Plan or the Marine Operations Manual.

2.3.2 The curves of righting moments are to be calculated and constructed in accordance with methods approved by the Register for the volume displacement ∇, in m^3:

.1 for a unit not kept from drifting by the positioning system,

$$\nabla = \frac{1}{\rho_l}\left(\Delta - \frac{P_V - P_R}{g}\right); \qquad (2.3.2.1)$$

.2 for a unit kept from drifting by the positioning system,

$$\nabla = \frac{1}{\rho_l}\left(\Delta + \frac{\sum_1^n P_{Pi} - P_V - P_S}{g}\right). \qquad (2.3.2.2)$$

The following symbols have been adopted in these formulae and in the subsequent text:

Δ is the mass of the unit, in t;

P_V is the vertical component of the wind load, kN;

P_R is the vertical component of the reaction arising when the unit drifts through the water, kN;

P_{Pi} is the vertical component of the force due to the *i*-th element of the positioning system ($i = 1,...,n$), kN;

P_S is the vertical component of the force due to current, kN;

ρ_l is the sea water density, t/m^3.

Action of the said forces on the unit is illustrated schematically by Fig. 2.3.2 wherein:

the righting moment, weight and buoyancy forces are involved (Fig. 2.3.2, *a*);

the wind load is involved: V_{V_0} is the true wind velocity; V_l is the drift speed over seabed (sailing speed); V_V is the relative wind speed (Fig. 2.3.2, *b*);

the forces due to drift and current are involved:

$V_l \neq 0$, $V_R = V_l - V_S$, V_S is the current velocity (Fig. 2.3.2, *c*);

the force due to current is involved: $V_l = 0$ (Fig. 2.3.2, *d*);

the force due to the *i*-th element of the positioning system is involved (positive direction) (Fig. 2.3.2, *e*).

(0 is the origin of coordinates in the unit's inclination plane, Y_x is the ordinates in the same plane).

In Figs. 2.3.2, *a* to 2.3.2, *e* apart from the specified forces and moments, the weight and buoyancy forces having no symbolic representation are involved.

2.3.3 The righting moment M_φ, in kN·m, is to be calculated by the following formula:

$$M_\varphi = \rho_l g \nabla (l_{\Phi_0} - z_g \sin\varphi - y_{g\chi} \cos\varphi) \qquad (2.3.3)$$

where z_g, $y_{g\chi}$ = the unit's centre of gravity coordinates in the inclination plane, in m;
χ = the relative direction of wind;
$l_{\Phi 0}$ = the cross-curves of stability in the inclination plane about the origin of coordinates, in m;
φ = the inclination angle, in deg.

2.3.4 Where the unit is provided with openings considered to be open (in the upper deck, sides, columns, superstructures, etc) through which water may enter the spaces, the curves of righting moments are to be calculated and constructed, if necessary, with the spaces flooded through those openings taken into account.

2.4 HEELING MOMENT CURVES

2.4.1 Heeling moment components.

2.4.1.1 For all loading conditions under consideration the curves of heeling moments M_h, in kN·m, due to wind moment M_v, in kN·m, normal to the most critical axis of the unit inclination as regards stability are to be plotted, as well as:

.1 for the units not kept from drifting due to wind, the hydrodynamic portion of the heeling moment M_R, in kN·m, is to be taken into account, so that

$$M_h = M_V + M_R + (P_V - P_R)[(z_g - d_f)\sin\varphi + y_{g\chi}\cos\varphi] \qquad (2.4.1.1.1)$$

where d_f = the unit draught, in m, along axis *z*, corresponding to displacement ∇ and inclination angle φ;

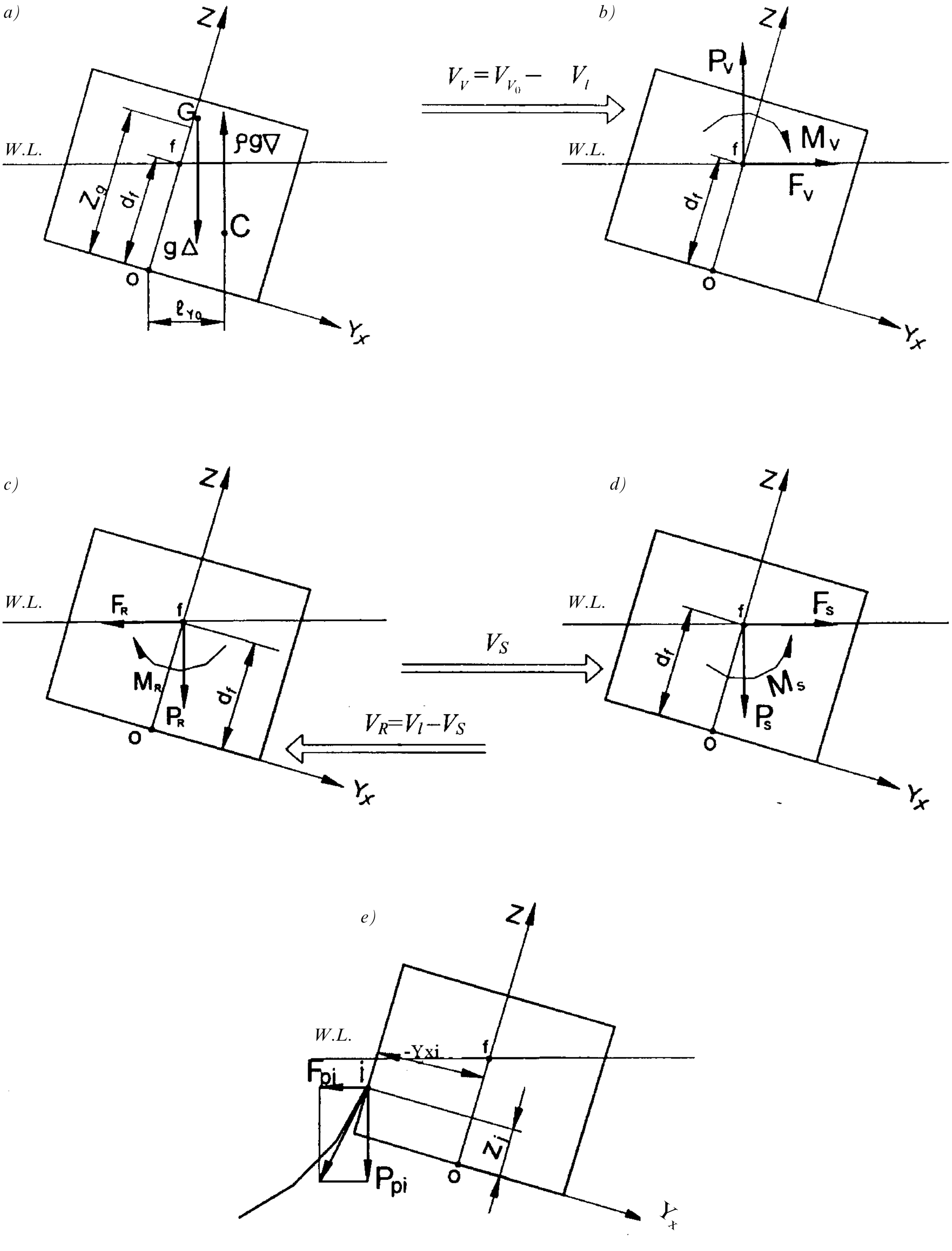


Fig. 2.3.2
Schematic illustration of the environmental effects in the unit's inclination plane

.2 for the units kept from drifting by the positioning system, the components of the forces produced by the position-keeping system and current are to be calculated and taken into account, so that

$$M_h = M_V + M_S + (P_V - P_S)[(z_g - d_f)\sin\varphi + y_{g\chi}\cos\varphi] + M_P \quad (2.4.1.1.2\text{-}1)$$

where M_s, P_s = the moment and vertical component of the forces due to current, in kN·m, kN, respectively;

$$M_P = \sum_i F_{Pi}\,[y_{gi\chi}\sin\varphi + (d_f - z_i)\cos\varphi] - \sum_i F_{Pi}[(z_g - z_i)\sin\varphi -$$

$$-(y_{\chi i} - y_g)\cos\varphi] \quad (2.4.1.1.2\text{-}2)$$

where F_{Pi} = the horizontal component of the force due to the i-th element of the position-keeping system, in kN;
z_i, $y_{\chi i}$ = the coordinates of the force point of the i-th element of the position - keeping system, in m;

.3 for the units held in position in the drifting ice with the use of anchors the components of forces due to ice load are to be calculated and taken into account using the procedures approved by the Register.

2.4.1.2 For the fixed structures, consideration is to be also given to the heeling moment due to forces P_w arising when the "skirt" touches the seabed.

2.4.1.3 The heeling moments M_V, M_R, M_S, in kN·m, and respective forces are to be generally determined by physical simulation methods using the procedures approved by the Register.

When no physical simulation data are available, the wind pressure and its lever with respect to the waterline, as well as the forces and moments due to drift and current may be determined by the method outlined in 2.4.2 to 2.4.4 and the ice load may be calculated using the procedures approved by the Register.

2.4.2 Wind heeling moment.

2.4.2.1 The wind pressure (horizontal component of the wind force) F_V, in kN, when the physical simulation data are used, is to be determined by the following formula:

$$F_V = C_V \frac{\rho_A}{2} A_V V_V^2 \quad (2.4.2.1\text{-}1)$$

where C_V = the wind resistance coefficient F_V referred to the unit's windage area A_V, in m^2, and to the dynamic wind pressure $\frac{\rho_A}{2} V_V^2$, in kPa, at the wind velocity profile V_V above the sea as given in 2.5.1.1.

N o t e . Where the coefficient C_V is referred to the windage area in the position inclined to an angle φ, this is to be accounted for in the calculations.

The lever of application of the wind pressure F_V with respect to the waterline h_F, in m, is to be determined by the following formula:

$$h_F = \frac{M_V}{F_V} \quad (2.4.2.1\text{-}2)$$

where M_V = the wind heeling moment with respect to the waterline, in kN·m.

The design air density ρ_A, in t/m^3, is to be determined by the formula

$$\rho_A = \frac{3{,}5\cdot10^{-3}p}{273 + t^\circ} \quad (2.4.2.1\text{-}3)$$

at such values of the atmospheric pressure p, in kPa, and the temperature t °C, characteristic for the area under consideration (and the season, where marine operations are involved) which result in the greatest values of ρ_A.

2.4.2.2 To account for the windage area of small items which are not installed on the model used in the physical simulation, the wind pressure F_V and moment M_V are to be increased by 2 and 5 per cent, respectively.

2.4.2.3 When no physical simulation data are available, a procedure outlined in Appendix 2 to the present Part may be used to construct the circle diagram. To do this, the wind pressure on the unit is to be previously determined for the wind flow in four directions differing by 90°, and then the wind pressure calculation is to be made following the instructions contained in Appendix 2.

In the approximate calculations, the wind pressure and its application lever are to be determined using the following formulae:

$$F_V = \frac{\rho_A}{2} A_{VA} V_V^2 \quad (2.4.2.3\text{-}1)$$

where

$$A_{VA} = \sum_j C_{Sj} C_{Hj} A_{Vj}\,, \quad (2.4.2.3\text{-}2)$$

and

$$h_F = \frac{\sum_j C_{Sj} C_{Hj} A_{Vj} h_{Vj}}{A_{VA}} \quad (2.4.2.3\text{-}3)$$

where A_{VA} = the windage area, in m^2;
A_{Vj} = the area of the j-th element of the unit, in m^2;
h_{Vj} = the area centre height above the waterline A_{Vj}, in m;
$C_{Hj} = (V_{hj}/V_V)^2$ = the height coefficient (zone coefficient) to be determined at $h_v = h_{Vj}$ by the Formula (2.5.1.1) and if $h_{Vj} \leqslant 10{,}0$ m the coefficient is assumed to be equal to 1 or is to be obtained from Table 2.4.2.3-1 for characteristic wind velocities.
C_{Sj} = the shape (aerodynamic flow) coefficient of the structural member; the coefficients C_{Sj} for some windage area components are given in Table 2.4.2.3-2.

2.4.2.4 For the units with the upper hull of rectangular shape and without large openings, if no physical simulation data are available, the wind heeling moment may be determined using the procedures outlined in Appendix 4 to the present Part.

2.4.3 Hydrodynamic portion of heeling moment.

2.4.3.1 For the unit not kept from drifting, the lever of application of the resistance force to drift h_R with respect to the waterline and the vertical

Table 2.4.2.3-1

Height coefficient C_{Hj}

Height above sea level, in m	V_V, in m/s		
	25,8	36,0	51,5
10	1	1	1
20	1,182	1,208	1,242
30	1,296	1,339	1,396
40	1,379	1,435	1,510
50	1,446	1,513	1,602
60	1,502	1,578	1,680
70	1,550	1,633	1,746
80	1,592	1,682	1,805
90	1,630	1,726	1,858
100	1,664	1,766	1,905
110	1,695	1,802	1,949
120	1,723	1,836	1,990
130	1,750	1,867	2,027
140	1,775	1,896	2,062
150	1,798	1,924	2,095
160	1,820	1,949	2,126
170	1,840	1,973	2,155
180	1,860	1,996	2,183
190	1,879	2,018	2,209
200	1,896	2,039	2,235
210	1,913	2,059	2,259
220	1,929	2,078	2,282
230	1,945	2,097	2,304
240	1,960	2,114	2,326
250	1,974	2,131	2,346

Note. The intermediate values of heights are to be determined by linear interpolation.

Table 2.4.2.3-2

Shape coefficient C_{Sj}

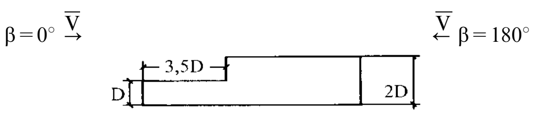
Windage area components	C_{Sj}
Spherical	0,4
Upper hull with that surfaces (hull shape in plan view):	
equilateral triangle when the wind flow is directed:	
along the bisectrix	0,65
normally to the side	1,01
square when the wind flow is directed:	
along the bisectrix	0,78
normally to the side	0,93
equilateral pentagon when the wind flow is directed:	
along the bisectrix	0,76
normally to the side	0,70
equilateral hexagon when the wind flow is directed:	
along the bisectrix	0,71
normally to the side	0,63
circle:	
with sharp edges of diameter R and height D	0,61
with rounded-off edges at a radius equal to half the height rectangle with side ratio:	0,32
$\lambda = B/L = 0,5$	0,89
$\lambda = B/L = 1,3$	0,96
(wind direction is normal to the face)	
Upper hull of rectangular shape in plan view with underdeck beams	1,1
Upper hull with upper structure 	0,63 (β=0°) 1,2 (β=180°)

Table 2.4.2.3-2 — continued

Windage area components	C_{Sj}
Superstructures, deckhouses, cabins and other box-type structures located:	
along the perimeter of the upper deck	1,2
in the centre part of the upper deck	0,7
Derrick substructure	1,2
Smooth cylindrical elements (bracing members, stabilizing columns, cylindrical legs) depending of the product of the design dynamic wind pressure q, in Pa, by the pipe diameter d_1, in m, squared	
at $qd_1^2 \leqslant 10$H	1,2
at $qd_1^2 \geqslant 10$H	0,7
Legs of square section	1,4
Lattice-type structures consisting of tubular elements (load-bearing structure of drilling derrick, crane booms)	1,3
Lattice-type legs of self-elevating units:	
tetrahedral	1,6
trihedral	1,5
Drilling derrick consisting of tubular elements with the drill pipe stands, linings of landings and ladders	1,7
Lining of the entire structure of the drilling derrick (conical)	0,7
Helideck (cantilever)	1,5
Isolated shapes	1,5
Hand rails	1,2
Small windage area components	1,4
Ropes of cargo handling gear	
with $\leqslant 20$ mm in diameter	1,2
with > 20 mm in diameter	1,0

Notes:

1. The windage area of the constituents of the unit A_{vj} is the characteristic area which is definitively related to the value of the unit resistance coefficient C_{sj}.

2. For structures with continuous surfaces (upper hull, superstructures, etc), the projected area of the hull to the vertical plane normal to the air flow velocity vector is to be taken as the characteristic area.

3. The projected area of lattice-type structures is to be obtained either by detailed calculations of the projected areas of the elements on the windward side having regard to unshielded areas inside the internal space (drill pipe stands, linings of ladders, etc) or by multiplying the projected block area on the windward side by a filling factor which is to be assumed equal to 0,45 for the drilling derricks and tetrahedral legs and 0,3 for trihedral legs, crane booms and other truss structures and tubular members.

4. When calculating the windage area of units with smooth cylindrical legs or stabilizing columns of circular and square sections, exposed to head and beam wind, projected areas of legs and columns are to be included with a shielding allowance being made.

The shielding factor for legs and columns of circular section is to be determined by the formula

$$K_3 = \exp(-0,002 + 1,033/\bar{l} - 20,4/\overline{l^2})$$

where $\bar{l} = l/d_1$;
l = the distance between the axes of legs or columns;
d_1 = the diameter of legs or columns.

The shielding factor for legs and columns of square section is to be determined by the formula

$$K_3 = \exp(0,005 - 0,79/\bar{l} - 30,4/\overline{l^2})$$

where $\bar{l} = l/b$;
b = the breadth of leg or columns side.

The shielding factor for the trihedral truss-type legs is to be assumed as: $K_3 = l/6b$.

The shielding factor for the tetrahedral truss-type legs is to be assumed as: $K_3 = l/9b$.

Table 2.4.2.3-2 — continued

5. Where two similar structural elements of non-streamlined form (deckhouses and superstructures of box type) are located on the deck one after another in the direction of the wind effect, shielding allowance is to be made by multiplying the area of the windward element by the shielding factor $K_3 = l/12c$, where c is the least projection of the element on a plane normal to the wind direction. In this case, the overall projection are of the windward element is to be included in the windage area. Where the elements differ in size, the portion of the rear element not overlapped by the windward element is to be included in full.
6. Where no data is available, it is to be assumed then $K_3 = L/7c$.
7. For the intermediate values of qd_1^2, the values of C_{sj} are to be determined by linear interpolation.
8. The continuity factor used in Appendix 1 is a product of the filling factor by the shielding factor.

component P_R of the forces acting on the unit being adrift are to be determined by physical simulation using the procedures approved by the Register.

2.4.3.2 Where the physical simulation data are not available, the lever of application of the resistance force to drift may be determined approximately (the vertical component of the forces acting on the unit being adrift may be taken equal to zero in this case):

.1 for the units whose hull has the shape close to the traditional body shape of ships or barges (at $B/d = 2{,}0$ — $6{,}0$), the lever of the resistance force to drift, in m, in case where the unit is inclined about the longitudinal axis may be determined by the following formula:

$$h_R = d[B/d - 3{,}00 - 0{,}02(B/d - 5{,}35)^3] \qquad (2.4.3.2.1)$$

where d, B = hull draught and waterline breadth, respectively, in m;

.2 for the units with underwater hull body consisting of structural members of non-streamlined form j, having the projected area to the vertical plane A_{Rj}, in m^2, the lever of the resistance force to drift may be obtained by the formula

$$h_R = \sum_j C_{R_j} A_{R_j} h_{R_j} / \sum_j C_{R_j} A_{R_j} \qquad (2.4.3.2.2)$$

where the coefficients C_{Rj} may be taken equal to the coefficients C_{Sj} for the appropriate shapes of members. When considering members, a shielding allowance is to be made.

2.4.3.3 The moment (lever) and the components of the forces due to current for an unit kept from drifting by the positioning system are to be determined in a manner like that specified in 2.4.3.2 with allowance made for the differences in signs (see Fig. 2.3.2).

2.4.4 Moments and forces produced by the position-keeping system.

The horizontal force F_P acting on the unit from the position-keeping system side, when the unit itself is not in contact with the seabed, is to be assumed equal to the sum of horizontal components of the wind pressure F_V and the load due to current F_S and reverse thereto in direction:

$$F_P = F_V + F_S. \qquad (2.4.4\text{-}1)$$

The heeling moment due to the position-keeping system is to be calculated with due account of the vertical component of these forces and corresponding change in the hydrodynamic forces. The assumed lever of the horizontal component of the forces due to the position-keeping system is to be determined as:

$$h_P = M_P/(F_V + F_S). \qquad (2.4.4\text{-}2)$$

The effect of the position-keeping system is to be calculated using the procedures approved by the Register.

2.5 DESIGN ENVIRONMENTAL (NATURAL) CONDITIONS

When selecting parameters of the design models of the environmental effects on the unit, the designer (on agreement with the customer) is to take account of such factors as:

differences in the design modes;

differences in the design conditions;

salient features of the geographical locations and duration of the construction, marine operations, transit, use of the unit;

seasonal fluctuations and local features of the environmental effects (wind, currents, waves, icing, etc);

sheltering of the water area;

possible restrictions due to hydrometeorological conditions;

accuracy of the weather forecasts;

peculiar features of the unit, etc.

2.5.1 Wind.

2.5.1.1 Height coefficient (of the area) $C_{Hj} = (V_{hj}/V_V)^2$ considering increasing of wind velocity V_{hj} on the basis of h_{vj} is to be determined by the formula

$$C_{Hj} = (V_{hj}/V_V)^2 = [1 + 2{,}5ln(h_{Vj}/10)\sqrt{(0{,}71 + 0{,}071V_V)10^{-3}}\,]^2 \qquad (2.5.1.1)$$

where V_V = design wind velocity (an average over the 10 min period velocity of a wind at a height of 10 m above the sea level), in m/s;
V_{hj} = wind velocity at a height h_{vj} above the sea level, in m/s.

2.5.1.2 The design wind velocity is to be specified by the designer on agreement with the owner of the unit on the basis of data from the recognized sources of the hydrometeorological information on the maximum value of the possible wind velocity at various stages of the unit life cycle:

.1 in the intended operating area

in the normal condition — every year,

in the survival condition — every 50 years;

.2 in the temporary condition, transit condition, afloat building and preparation modes: with due account of their duration, location and season, sheltering of the water area (e.g. shore-side structures, configuration of terrain, lakes, bays, rivers, flooded areas, etc).

2.5.1.3 Where no data mentioned in 2.5.1.2 are available, the design wind velocity is assumed to be as follows:

in the normal condition in the open water areas: 36 m/s; and in the sheltered water areas: 25,8 m/s;

in the survival condition in conformity with Annex 4 to the present Part, and where no data are contained therein: 51,5 m/s;

in the temporary condition, transit condition, in the afloat construction and preparation modes where the operation lasts not more than three hours , in conformity with the Builder's Instructions (with due account of the local and seasonal conditions), and in case of a longer period of the operation: 25,8 m/s in the sheltered water areas and 36 m/s in the open water areas.

2.5.2 Waves.

2.5.2.1 The effect of the waves is to be allowed for only in the seasons when there is no ice.

2.5.2.2 Waves are to be specified and described by the following design parameters:

$h_{3\%}$ which is the wave height with 3 per cent probability of exceeding, in m;

T which is the mean period of heavy waves, in s;

χ which is the general wave direction.

The values of $h_{3\%}$, T and other parameters of the spectral wave density are to be taken consistent with the design wind force with due account of the local peculiarities of wave generation and when marine operations are performed, consideration is to be also given to the season.

The design parameters of the waves are to be agreed with the Register and indicated in the Information on Stability and in the Marine Operations Manual.

2.5.2.3 The design wave height (unless otherwise specified) is to be taken on the basis of the long-term probability (multi-year) distribution of heights $h_{3\%}$, as a height with 50 per cent probability of exceeding at the design wind force.

2.5.2.4 In the temporary condition the design wave height is to be specified by the designer on agreement with the owner of the unit, but it is not to be taken lower than that given below:

in the sheltered water areas — 0,5 m;

in the open water areas — 2,0 m.

2.5.2.5 In the survival condition the design wave heights are to taken for the area involved as the greatest heights from the multi-year observation data and where no such data are available, according to Appendix 4 to the present Part, but on no account they are to exceed:

16 m for the seas of the Arctic Ocean (Russian sector) and the Pacific Ocean (Russian sector);

14 m for the Baltic and Caspian Seas;

12 m for the Black Sea;

6 m for the Azov Sea.

2.5.3 Current.

2.5.3.1 The effect of current is to be taken into account only in cases where the position-keeping system is used and where the total velocity of the components accounted for (of the wind, drift, gradient, tidal, discharge and other kinds of current) exceeds 0,5 m/s. The design velocities of the wind current and wave drift on the water surface are to be taken as having 50 per cent probability of exceeding at the design parameters of wind and waves .

In case where the vector of the total velocity of surface current does not coincide with the unit inclination plane for its orientation pattern adopted, the current velocity multiplied by the cosine of the angle between the wind and current directions is to be taken as the design current velocity.

2.5.3.2 The used data on currents are to be agreed with the customer (owner of the unit) and the procedure of calculating the current effects is to be approved by the Register.

2.5.4 Floating (drift) ice.

2.5.4.1 Stability calculation of a unit with a position-keeping system is to be made with due account of the drift ice effect on the unit.

2.5.4.2 Marine operations, as a rule, are not to be performed in water areas covered by floating ice.

Where such operations are performed with the drift ice present and no special measures are taken to reduce ice forces (such as ice breaking by explosions, breaking down of ice near a structure with the use of icebreakers, etc), the stability calculation is to be made with due account of the ice forces.

2.5.4.3 The following procedures are to be submitted to the Register for approval:

calculation of the effect of ice forces on stability;

model tests in drift ice;

use of the model test data for evaluating stability.

2.5.5 Ice and snow accretion.

2.5.5.1 Where a marine operation is performed in winter within winter seasonal zones set up by the Load Line Rules for Sea-Going Ships and the unit is operated within a winter seasonal zone, stability of the unit and supply vessels with due regard for ice and snow accretion is to be checked in addition to the main loading conditions.

2.5.5.2 When calculating stability with regard to ice and snow accretion in a first approximation use may be made of the following recommendations:

.1 for units operating within winter seasonal zones to the north of latitude 66°30′N and to the south of latitude 60°00′S, as also in winter in the Bering Sea, the Sea of Okhotsk and in the Tatarski Strait, the assumed rates of ice and snow accretion are to be as specified below:

the mass of ice per square metre of the horizontal projection area of exposed decks (irrespective of the availability of awnings) is to be 30 kg, if those decks are located at a height up to 10 m above the waterline, 15 kg, if the height is from 10 up to 30 m, and if the height above the waterline is more than 30 m, the mass of ice may be neglected;

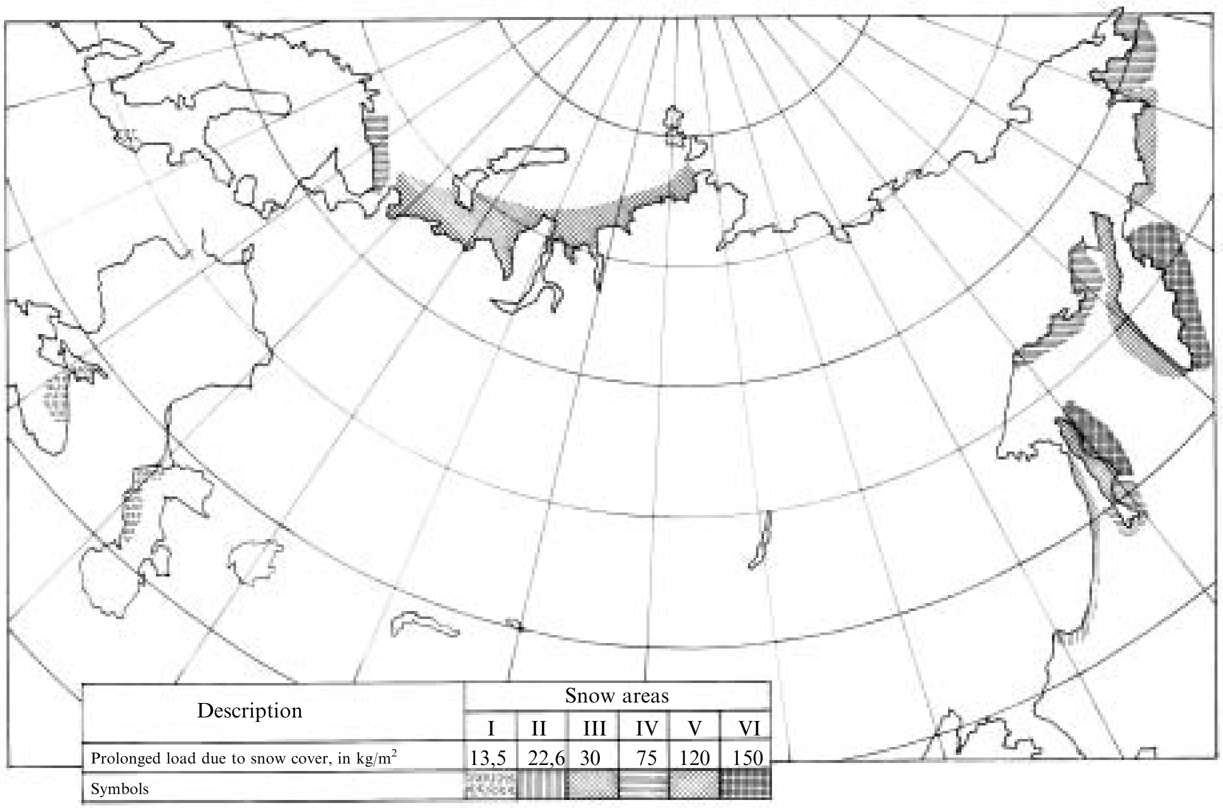
the mass of snow per square metre of the area of the above-mentioned decks (irrespective of the height) is to be 100 kg for unmanned units and 10 kg for manned units, or with the geographical service area of the same units prescribed, the mass of snow is to be as given in Fig. 2.5.5.2.1;

the mass of ice per square metre of the windage area is to be 15 kg, if the height above the waterline is up to 10 m, 7,5 kg, if the height is from 10 up to 30 m, and if the height is more than 30 m, the mass of ice may be neglected;

.2 in other areas of the winter seasonal zone, as well as for the units operating in the Black and Azov Seas northwards of latitude 44°00′N and in the Caspian Sea northwards of latitude 42°00′N, the rates of ice and snow accretion are to be assumed to be equal to half those specified in 2.5.5.2.1, except for the areas where, on agreement with the Register, ice and snow accretion need not be taken into account.

2.5.5.3 To account for the projected lateral areas of discontinued surfaces of units subjected to icing the projected lateral area and its moment of continuous surfaces with respect to the base plane are to be increased by 10 and 20 per cent or 7,5 and 15 per cent, respectively, depending upon the rates of icing stated above.

2.5.5.4 Special facilities to reduce ice and snow mass are to be considered in the design of units.



Description	Snow areas					
	I	II	III	IV	V	VI
Prolonged load due to snow cover, in kg/m²	13,5	22,6	30	75	120	150
Symbols						

Fig. 2.5.5.2.1

3 STABILITY CRITERIA

3.1 GENERAL

3.1.1 The stability criteria given in the present Section are obligatory for all units. These criteria are to be determined in accordance with Fig 3.1.1-1, if the unit motions are accounted for and in accordance with Fig 3.1.1-2, if the unit motions are ignored.

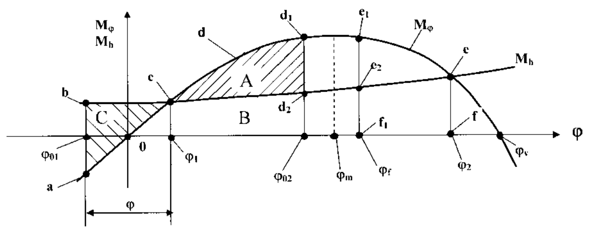


Fig 3.1.1-1
Curve of statical stability with the motions allowed for:
M_φ is the righting moment;
M_h is the heeling moment;
φ_{01} is the angle of dynamical inclination to the windward side due to waves;
φ_1 is the first intercept angle of the curves M_φ and M_h;
φ_{02} is the angle of inclination due to combined action of the wind and waves on the leeward side;
φ_m is the angle of maximum of the righting moment curve M_φ;
φ_f is the angle of flooding;
φ_2 is the second intercept angle of the curves M_φ and M_h;
φ_v is the angle of vanishing stability;
φ_r is the motion amplitude.

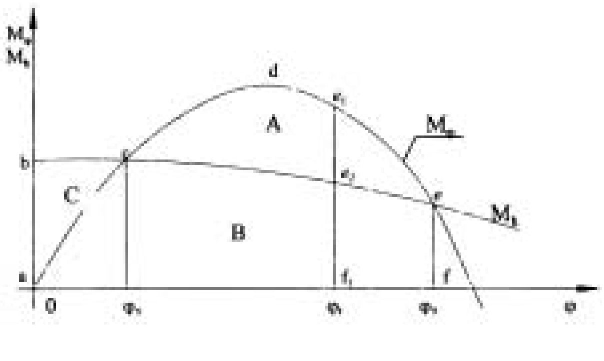


Fig. 3.1.1-2
Curve of statical stability with the motions ignored

The areas sought in the above Figs. 3.1.1-1 and 3.1.1-2 are to be determined as follows:

area A — by figure *cde* (or cde_1e_2 if the angle of flooding φ_1 is less than the angle of second intercept φ_2);

area B — by figure *ocef* (or oce_2f_1, if $\varphi_1 < \varphi_2$);

area C — by figure *abc*.

3.1.2 When checking stability of the units, on agreement with the Register, alternative stability criteria may be considered provided an equivalent level of safety is maintained, which takes into account the following:

environmental conditions representing realistic effects exerted on the unit, which are appropriate for specific areas during the stipulated periods of use;

potential for occurence of circumstances inadequately allowed for in the calculations, by introducing adequate safety margins.

3.1.3 The corrected initial metacentric height is to comply with the requirements set forth below.

The corrected initial metacentric height h_0 for all types of units corresponding to an inclination about any horizontal axis is to be not less than:

0,3 m — during marine operations;

0,6 m — during service;

1,0 m — during operation of units with stabilizing columns;

after completing the operation of launching from a barge, the unit is to remain afloat in stable equilibrium with a positive metacentic height.

3.1.4 Where openings considered to be open

$$h_0 \geqslant 60 \frac{m}{\Delta} \frac{l_f}{\varphi_n^\circ}, \text{ m} \quad (3.1.4\text{-}1)$$

where m/Δ = the ratio of the greatest load moved over the unit to the displacement of the loading condition under consideration, but not less than 0,01;

φ_n° = the permissible angle of inclination, in deg., equal to

$$\varphi_n^\circ = \varphi_f - 35/l_f, \quad (3.1.4\text{-}2)$$

but not more than 15° (φ_f is the least angle of flooding through the openings considered to be open; l_f is the horizontal distance from the inclination axis to the opening at the inclination angle equal to zero).

3.1.5 Subject to special consideration by the Register is to be stability of:

a barge during and after launching of the unit;

a unit launched from a barge;

vessels and water craft (barges, support assemblies, buoyancy/stability pontoons, etc) involved in marine operations;

floating structures with excessive buoyancy and pre-tensioned anchor-mooring system.

3.2 DESIGN AMPLITUDE OF MOTIONS

3.2.1 The design amplitude of the unit's motion φ_r is the amplitude of oscillation around the inclination axis , which is induced by wind waves running against the unit from a direction normal to the inclination axis . The design amplitude of motion has 1,1 per cent probability of exceeding and is assumed to be equal to:

$$\varphi_r = 3\sqrt{D_\varphi} \qquad (3.2.1)$$

where D_φ = the motion variance, in deg.^{2} (rad.^{2}).

3.2.2 The design amplitude of motion is to be determined with due account of the water depth (if the water depth is less than $0{,}03gT^2$), and where the position-keeping system is used, with due account of its effect. In the survival condition, the motion amplitudes are to be determined under various modes of failures to the position-keeping system.

3.2.3 The design motion amplitude is to be determined using the procedures approved by the Register.

3.2.4 Where physical simulation is used to determine the motion amplitude, the following procedures are to be submitted to the Register for approval:

procedure of the unit model tests;

procedure for using the model test data to evaluate the amplitude of motion.

3.2.5 The height of the lower edge of openings considered to be open above the wavy sea surface, h_f, in m, and to be taken as stated in the formula given below, but not less than 0,6 m, is recommended to be considered as one of the stability criteria:

$$h_f = h_{f_0} - 3\sqrt{D_{h_f}} \qquad (3.2.5)$$

where h_{f_0} = the height of the opening above the sea surface in calm water, in m;
D_{h_f} = the variance of immersions of the lower edge of openings in the seas, in m^2.

3.3 REQUIREMENTS FOR THE CURVE OF STATICAL STABILITY

3.3.1 The righting moment curve M_φ, in kN·m, is to be positive over the entire range of inclination angles from angle $\varphi = 0$ to the second intercept angle φ_2 of the above curve M_φ with the heeling moment curve M_h, in kN·m.

3.3.2 The area under the righting moment curve M_φ between the first intercept angle φ_1 and the second intercept angle φ_2 (or to the angle of downflooding φ_f through an opening considered to be open, if $\varphi_f < \varphi_2$) without regard for the motion is to be not less than 30 per cent or 40 per cent in excess of the area under the curve M_h to the same limiting angle, depending on the type of the unit; where motion is taken into account, the ratio between the areas is to be agreed with the Register.

3.3.3 The angle of inclination due to combined action of wind and waves on the leeward side φ_{02}, to be determined on the assumption that the areas A (cd_1d_2) and C (abc) (see Fig. 3.1.1-1) are equal, is not to be in excess of the angle of the maximum heeling moment curve M_φ, that is φ_m.

3.3.4 The curve M_φ is to intersect the curve $1{,}7M_h$ or at least is to be tangent thereto.

3.3.5 In all cases the righting arms $l_\varphi = M_\varphi / g\Delta$, in m, are not to be less than those given in Table 3.3.5 when ho is equal to 0,30 m.

Table 3.3.5

φ, deg.	0	10	20	30	35	40	45	50	55	60
l_φ, m	0	0,060	0,151	0,242	0,264	0,257	0,220	0,156	0,077	0

3.4 ADDITIONAL REQUIREMENTS FOR STABILITY

3.4.1 Semi-submersible units.

3.4.1.1 In addition to the requirements of 2.2, stability of semi-submersible units is to be checked also for the following loading conditions:

.1 in normal condition with maximum drilling stores in the upper hull, with complete set of drill pipes fitted in regular positions;

.2 in survival condition when the unit is disconnected from the well, drill pipes are secured in racks, the unit is changed to a new draught, the drilling stores are relocated (if necessary) to the pontoons and columns;

.3 in transit condition with maximum transit stores;

.4 when being raised or lowered with maximum transit stores.

3.4.1.2 Stability of semi-submersible units is considered to be adequate provided the following requirements are met:

.1 under conditions referred to in 3.4.1.1 the areas A, B, C (see Fig. 3.1.1-2) meet the following condition, and where roll is taken into account (see Fig. 3.1.1-1) the ratio between the areas is to be agreed with the Register

$$(A + B) \geqslant 1{,}3(B + C); \qquad (3.4.1.2.1)$$

.2 in transit condition under loading referred to in 3.4.1.1.3 the angle of inclination corresponding to the maximum of the righting moment curve M_φ is to be greater than the amplitude of motion at sea state by 1 point in excess of that for which transit is designed.

3.4.2 Self-elevating units.

3.4.2.1 In addition to the provisions of 2.2, stability of self-elevating units is to be checked also in transit for the following loading conditions:

.1 with legs in elevated to the utmost position with full transit drilling stores and 10 per cent of sea stores;

.2 with legs lowered to 30 per cent into water and with full transit stores.

3.4.2.2 Stability of self-elevating units is considered to be sufficient if under the loading conditions referred to in 3.4.2.1 the areas A,B,C (see Fig. 3.1.1-2) meet the following condition and where the motion is taken into account (see Fig. 3.1.1-1) the ratio between the areas is to be agreed with the Register

$$(A+B) \geqslant 1{,}4(B+C). \qquad (3.4.2.2)$$

3.4.3 Submersible units.

Stability of submersible units is to be checked in the transit condition, as well as during lowering and raising. In this case, the areas A, B, C (see Fig. 3.1.1-2) are to meet the condition (3.4.1.2.1) and where the roll is taken into account (see Fig. 3.1.1-1) the ratio between the areas is to be agreed with the Register.

3.4.4 Sea-going ships.

3.4.4.1 Stability of sea-going ships to which provisions of 1.1.1.3 apply, when in the normal condition and under the worst loading condition, as far as stability is concerned, is to be agreed with the Register.

Calculations of the windage area, ice and snow accretion effect are to be made in accordance with 2.4.2 and 2.5.5.

3.4.4.2 Stability of sea-going ships to which provisions of 1.1.1.3 apply, in the transit and icing condition are to meet the requirements of Part IV "Stability" of the Rules for the Classification and Construction of Sea-Going Ships.

3.4.5 Fixed units.

Stability of fixed units is to be checked in the temporary condition. In this case, the areas A,B,C (see Fig. 3.1.1-2) are to meet the condition (3.4.1.2.1) and where the motion is taken into account (see Fig. 3.1.1-1) the ratio between the areas is to be agreed with the Register.

APPENDIX 1

STABILITY CALCULATION OF A UNIT

The order and scope of the information on calculations, including stability calculation, is recommended to be as follows:

1. Introduction specifying the aim of the calculation.
2. Initial data listing the unit characteristics necessary to perform calculation.
3. Accepted methods and schemes of performing calculation; initial calculation formulas, coefficients etc. with references to the sources (the list of sources is set out at the end of calculation).
4. The list of software used and the information on its approval by the Register.
5. Calculation as such.
6. The results of calculation represented (as far as possible) as graphs, diagrams, charts, tables etc.
7. Conclusion.
8. Appendices with additional initial and calculation data (if necessary).
9. The list of sources.

APPENDIX 2

GUIDANCE FOR THE CONDUCT OF AN INCLINING TEST OF MODU/FOP AND THEIR MODULES

The present Guidance sets forth requirements and recommendations for the preparation, conducting and processing of the results of the inclining test of the MODU/FOP and their modules (herein referred to as "units") at different stages of assembly afloat and prior to the main marine operations.

Inclining tests for the units having the ship hull form and ratio of dimensions is to be carried out in accordance with 1.5, Part IV “Stability” of the Rules for the Classification and Construction of Sea-Going Ships.

The need for the inclining test of a unit is dictated by the criteria given in 1.5, Part IV "Stability" of Rules the Classification and Construction of Sea-Going Ships.

Where conduct of the inclining test of a unit in accordance with the present Guidance is impossible or severely hampered by circumstances of technical nature dependent on local conditions, then, on agreement with the Register, the inclining test may be conducted by other method chosen by the inclining test commission and approved by the Register.

1 GENERAL

1.1 The purpose of the inclining test of a unit is determination of its displacement and position of centre of masses (centre of gravity).

1.2 To conduct the inclining test, an Inclining Test commission is to be appointed, headed by the chairman. The commission is to incorporate representatives of the builder, designer and customer (owner of the unit).

1.3 The commission is to be in charge of the preparation, conduct and processing of the test results and is to be responsible for quality and accuracy of the test results.

1.4 The requirements of the commission applied to preparation, conduct and processing of the results of the inclining test are mandatory for all persons participating in and responsible for the test.

1.5 All departures from the requirements of the present Guidance, unless they deteriorate quality of the inclining test, are to be adopted by the chairman of the commission, indicated and justified in the Inclining Test Report.

Form of the Inclining Test Report is given in Appendix 2.1 to the present Guidance.

1.6 Prior to the inclining test, the commission is to:

detail and explain responsibilities of all persons directly involved in the inclining test;

assign time and place for the inclining test, having sufficient depth and protected from wind, waves induced by wind or passing ships, and currents;

work out the mooring method to allow unrestricted inclinations of the unit.

1.7 The water area in the location where the inclining test is conducted is to be free of ice and objects which hinder inclination of the unit and movement of craft around it when draught (freeboard) readings are taken.

1.8 The depth of water under the most immersed part of the unit’s bottom during inclinations is to be not less than 2 m where there is no liquid mud in the water to that depth (Record according to the form given in Appendix 2.1.2).

1.9 Where there is a current, the unit is to be placed along the current.

1.10 The inclining test is to be conducted in calm weather, under ripple or smooth sea up to force 1 (wave height with 3 per cent probability of exceeding up to 0,25 m) conditions and at wind velocity not more than 2 m/s (Record according to the form given in Appendix 2.1.2).

1.11 The wind velocity and direction are to be measured at the beginning and at the end of the inclining test and also simultaneously with the heel angle measurements during inclination of the unit.

1.12 Prior to the inclining test, the analysis of parameters sensitivity affecting the test results is to be made. Such parameters are the draught, angle of heel, sea water density, heeling weights and weight movement distances, varying wind velocity, accuracy of measuring equipment, etc.

The sensitivity analysis is to give the total expected error in determination of the position of centre of gravity and also to show what parameters are to be taken into account during the test.

2 LOADING OF THE UNIT DURING THE INCLINING TEST

2.1 The inclining test of a unit is to be performed in the following loading conditions:

.1 loading condition corresponding to launching at the period when the unit was built;

.2 loading condition close to light-weight condition (as per design);

.3 loading condition prior to the main marine operations.

This is especially true where the design value of metacentric height is close to its minimum permissible value and where such condition results from the movement of heavy weights.

The repeated inclining test may be required if under the design change in the mass loading of the unit when passing from the condition 2.1.1 to the condition 2.1.2 the requirements of the present Part are violated at

$$Z_g = 1,2Z_{g2} - 0,2Z_{g1}$$

where Z_{g1} is the design vertical centre of masses of the unit in condition 2.1.1;
Z_{g2} is the design vertical centre of masses of the unit in condition 2.1.2 ($Z_{g2} > Z_{g1}$);
Z_g is the assumed vertical centre of masses under test conditions.

2.2 The trim of the unit during inclining test is to be such that the actual waterline during inclinations of the unit does not intersect the bottom surface, for which purpose equalizing ballast may be taken, if necessary, in such an amount as to ensure specified position of the actual waterline.

Upon agreement with the Register, water ballast may be considered as equalizing ballast. Tanks (compartments), which contain equalizing water ballast, are to mandatory be pressed up and free from free surfaces ("air pockets").

2.3 Loading conditions of the unit consistent with its conditions during the inclining test are to be provided for in preliminary calculations for control and comparison with the results of the inclining test.

2.4 The total mass of missing loads may be not more than 2 per cent of the unit's displacement under test conditions Δ_{test}.

The mass of surplus loads including heeling ballast and equalizing ballast according to 2.2 is not to exceed 4 per cent of the unit's displacement under test conditions Δ_{test}.

2.5 The metacentric height of the unit during the inclining test is to be not less than 0,05 the vertical centre of gravity.

2.6 Personnel of firms and organizations together with their tools, equipment, except for persons directly involved in or responsible for the inclining test, all foreign objects (loads) which form no part of the mass loading of the unit during the inclining test, as well as debris and snow are to be removed from the unit.

2.7 No icing of the external and internal surfaces of the unit including the underwater body thereof is to be permitted.

2.8 The following items may be left on board the unit prior to the test:

liquids in the onboard machinery, apparatus, piping systems to keep them operating;

fuel and lubricating oil in the daily service tanks, boiler feed water to provide conduct of the inclining test and operation of boilers to meet the heating needs in winter;

fresh (drinking and washing) water in daily service tanks.

2.9 The inclining test commission in each particular case is to explore the possibility of leaving tankage and liquid cargo stock (see 5.3) on board the unit being subjected to the inclining test, and based on such exploration, the commission is to make a decision agreed with the Surveyor to the Register who attends the test.

3 TEST WEIGHTS

3.1 To provide inclination of the unit, use is to be made of the following:

solid weights;

water ballast;

people running athwart ships in unison;

unit's own cargo cranes.

Inclination of the unit by water ballast may be performed by two methods:

.1 with heeling tanks pressed up;

.2 with heeling tanks being slack at all times.

When water ballast is used for inclination account is to be taken of the following:

tank shape, volume and volume center;

structural features of tanks intended for the heeling ballast;

possibility to eliminate effectively the free surfaces ("air pockets") when pressing up the heeling tanks.

3.2 Where the test weights are placed on one side of the unit, inclination to 2 to 4° is to be provided. For units with large displacement and excessive initial metacentric height inclination may be reduced to 1°.

3.3 Where water ballast is used for inclination, provision is to be made for the most accurate determination of the volume and volume centre for each tank used for heeling ballast, arrangement and volumes of the internal stiffeners and equipment of these tanks, compilation of the tank calibration tables. Compliance of the tanks with their drawings is to be verified on the spot. The form of the Record of determination of the heeling water ballast mass is given in Appendix 2.1.8.

3.4 The levels and amount of the tankage in tanks, where inclination is made using the first method, are to be measured after each transfer of the heeling ballast. The effect of free surfaces of the tankage consisting of heeling ballast and liquid cargoes on the inclining test performance is to be negligible, which in each particular case is to be evaluated by the commission on the basis of the following criterion. The free surface correction to the design value of the metacentric height h, corresponding to the mass loading condition of the unit during the inclining test is to be at a time not more than:

0,002h for each individual tank containing the tankage consisting of heeling ballast or liquid cargo;

0,01h in total for all tanks containing the tankage consisting of heeling ballast or liquid cargo.

When determining the corrections, moments of inertia of the free surfaces are to be calculated at initial heel of the unit with due account of the liquid density.

Inclination angles induced by cross-flooding of the tankage are to be so small that they cannot be recorded by instruments intended to measure the inclination angles during the inclining test.

3.5 Each time when tanks are filled with the heeling ballast, consideration is to be given to absolute absence of the air pockets after the heeling tanks have been pressed up.

3.6 If because of structural features of the tanks or for other reasons, the complete elimination of the air pockets from pressed up heeling tanks is impossible, the second method of inclination is used with transfer of the heeling ballast from side to side when free surfaces are present at all times.

The free surfaces are to be of rectangular shape and of the same size in the starboard and port tanks, invariable at the upper and lower levels of the heeling ballast being transferred.

The upper and lower levels of the free surface in a tank are to be set within the wall-sided portion of the tank. These levels at the tank corners are to be marked by clearly distinguishable lines accessible for observation through the upper manholes (hatches) with the use of portable lighting, or are to be determined by other reliable means.

3.7 Movement of the centre of mass of the test weights transferred from side to side is to be close to a transverse-horizontal one.

The amount of the heeling water ballast on board the unit during the inclining test is to remain constant and is to necessarily be checked just before and immediately after the inclining test.

3.8 To provide inclination of the unit, use is to be made, if possible, of tanks rather narrow breadthwise. Such tanks are beneficial for:

decrease of the error in determination of the heeling moment;

decrease of the free surface effect of the water ballast tankage when the first method of inclination is used;

more efficient elimination of the air pockets when the first method of inclination is used;

improvement of the accuracy in accounting for the free surfaces of heeling ballast when the second method of inclination is used.

3.9 The free surface correction to the initial metacentric height is to be accounted for in processing the results of the inclining test.

4 DEVICES FOR MEASUREMENT OF INCLINATION ANGLES

4.1 The dominant devices for measurement of inclination angles of the unit during the inclining test are U-tubes (three or more) or optical quadrants (two or more) to be located in different positions on the unit, longitudinally.

If there is a need to measure the angles of trim, three more U-tubes or two more quadrants located on the unit, transversely, are to be used.

4.2 Base length of the U-tube (distance between the measuring tubes) is to be sufficiently large to improve the accuracy of measurements of the inclination angles and to be consistent with the length of the tubes themselves or of the measuring rules. In any case, the minimum base length of the U-tube is to be not less than 13 to 15 m.

Measurements of the inclination angles with the use of the U-tubes are to be made by persons who have experience in handling such devices.

4.3 The measuring rules with millimetric scale for taking the liquid level readings in the U-tubes are to be positioned vertically at the ends of the base length and attached securely together with the U-tubes to the fixed hull structures of the unit. In the initial position of the unit the water level in the U-tube is to be approximately at the mid-length of the tube (measuring rule).

The liquid level in the U-tube may be measured not by a measuring rule but by a declivity board (measuring batten) with a clean freshly planed surface provided instead. The form of the Measurement Record is given in Appendix 2.1.5.

4.4 To ensure adequate accuracy in measuring the inclination angles, the U-tubes are to be filled with a homogenous coloured liquid which does not freeze at sub-zero air temperatures during the inclining test.

When making measurements, no sharp bends of the U-tube hoses are permissible, the U-tube is to be free of air bubbles, solid particles and impurities.

4.5 In well-grounded cases, on the Inclining Test Commission's decision, the inclination angles may be measured by pendulums, inclinometers and other special devices, and in doing so, in each individual case use is to be made of devices of the same type or with identical accuracy of measurement.

Where pendulums are used, their length is to be at least 6 to 7 m.

5 PREPARATIONS FOR THE INCLINING TEST

5.1 Prior to the inclining test, the unit's trim is to be such that the requirements of 2.2 are met.

As a rule, the unit is to have no initial heel, or as a last resort, the heel must not exceed 0,3°. Trim compensation is not required.

The initial heel is to be measured by devices referred to in Section 4 on reference lines (verification base) of the unit's hull, to be fitted before the unit is launched.

5.2 A careful preparation of the liquid cargo tanks for the inclining test is a central prerequisite for assuring its successful performance.

When pressing up tanks for liquid cargoes (including heeling ballast) measures are to be taken to prevent formation of air pockets. Not earlier than in 1,5 to 2,0 hours after pressing, the tanks are to be inspected, the air pockets detected in the process are to be completely removed. Methods to remove air pockets are to be established by the inclining test commission in each particular case. As directed by the commission, samples of liquid cargoes may be taken in order to determine density thereof.

5.3 Immediately prior to the inclining test of the unit, its spaces and containers: compartments, cofferdams, tanks (including small tanks and canisters), etc are to be subjected to inspection in order to ascertain whether they contain liquid cargoes, a Record of their readiness for the inclining test (in accordance with the form given in Appendix 2.1.6) is to be drawn up and a table of conditions of spaces and containers with liquid cargoes is to be compiled immediately prior to the inclining test (in accordance with the form given in Appendix 2.1.7).

All spaces and containers which, proceeding from the test conditions, must not contain liquid cargoes are to be carefully dried. With permission of the inclining test commission, the hard-to-reach locations may contain some liquid cargo remains, which cannot be removed by standard means and do not affect the inclining test performance.

5.4 All variable loads included into the design loading condition of the unit during the inclining test are to be stowed in regular positions and secured. At the discretion of the commission, masses of these loads may be determined by weighing or according to the data of technical documentation.

For all loads which are surplus (missing) in relation to the design loading condition of the unit during inclining test, records are to be drawn up in accordance with the form given in Appendix 2.1.3.

5.5 The devices for measuring the inclination angles of the unit are to be positioned as specified in Section 4. Verification of their positioning is to be entered in a record to be prepared in accordance with the form given in Appendix 2.1.10.

Provision is to be made for an adequate illumination of measuring rules, scales of instruments and locations where freeboard (draught) readings are taken.

5.6 The following documents are to be submitted to the inclining test commission:

Record of acceptance of the principal dimensions of the unit to be drawn up in accordance with the form given in Appendix 2.1.1 (particular care is to be given to the depth measurement in those locations where freeboard readings are taken as the unit's trim is determined);

Record of acceptance of the draught marks (if any). The draught marks are to be cleaned and brightly coloured.

5.7 Small boats or rafts (at the commission's discretion) are to be available to aid in taking of freeboard and draught mark readings (if the draught marks are provided).

5.8 To take freeboard readings from the unit's deck, it is advisable to use a metal measuring tape which length exceeds the expected freeboard during the inclining test. A glass tube open at both ends, graduated in 5 mm, of at least 250 to 300 mm in length and not less than 5 mm in diameter is to be attached to the free end of the measuring tape. The lower end of the tube is to be fitted over a rubber hose of 3000 to 5000 mm in length. A plumb bob is to be suspended on the free end of the hose to impart an upright position to the hose in water. Under condition where there is ripple on the water surface, which does not rock the unit, such a hose makes it possible to measure in the tube, with an adequate accuracy, the level of calm water unsusceptible to the effect of surface wave fluctuations.

A similar device but without measuring tape may be used to take the unit's draught mark readings (if any).

The number of devices used for taking freeboard (draught) readings is to be not less than three, lengthwise. The freeboard readings taken are to be documented in the form of a record to be prepared in accordance with the form given in Appendix 2.1.4.

5.9 A plan of stationing of the participants in the inclining test is to be drawn up. The following commands (signals) are to be established:

"Stand by taking readings", "Start taking readings", "Stop taking readings". These commands (signals) are to be heard (seen) in all places on board where people stay during the test. The form of a record of stationing of the participants in the inclining test is given in Appendix 2.1.9.

5.10 Communications are to be provided between control station of the inclination test commission chairman and the U-tube (quadrant) observer stations, locations where freeboard and draught mark readings are taken, mooring line stations, etc.

5.11 Since the commencement of preparations for the inclining test, no loads are to be taken, removed or moved on board the unit without permission of the inclining test commission chairman.

6 INCLINING TEST PROCEDURE

6.1 To conduct the inclining test, a water area complying with the requirements of 1.6 to 1.10 is to be allocated.

6.2 The unit is to be held by lines at the bow and at the stern, secured at the centreline. The lines are to be as long as practicable. It is advisable to have not more than two (as a last resort, four) mooring lines. During the test, in the intervals between commands: "Stand by taking readings" and "Stop taking readings" the lines of the unit are to be as much slack as practicable. If there is a current, the bow line secured at the centreline need not be slacken to hold the unit against the current.

6.3 Immediately before the test, a survey is to be carried out to make sure that the unit is properly prepared for the test. The survey is to include also an inspection and check against the following records drawn up previously:

all tanks, compartments, machinery, piping, etc to verify preparation of the liquid cargoes for the test;

open decks and all spaces of the unit to verify presence and stowage of variable loads;

stationing of the participants in the test at the command (signal): "Stand by taking readings";

correctness of initial positioning of heeling ballast.

Immediately upon completion of measurements, condition of the unit is to be rechecked.

Prior to the test, a sample of sea water is to be taken from a depth equal to one-half the unit's draught in order to determine density of the water, and its temperature is to be measured.

6.4 All measurements of the unit's inclination angles, wind direction and velocity (Record in accordance with the form given in Appendix 2.1.2), the unit's direction in relation to current are to be taken only in the intervals between the signals: "Start taking readings" and "Stop taking readings".

6.5 The readings of freeboard and draught marks (if any) are to be taken twice: immediately before and immediately after the test.

At the discretion of the inclining test commission, measurements are to be taken either simultaneously on both sides in the same transverse plane or simultaneously at all measurement locations. Each boat or raft used to take measurements is to carry at least two observers.

With no water surface oscillation (or if its swing does not exceed 50 mm), only metal measuring tapes without additional fixtures referred to in 5.8 are to be used.

6.6 The need for an account to be taken of the unit's hull deflection when the unit's displacement and vertical centre of buoyancy are determined during the test, is to be identified by the inclining test commission on the basis of the unit's general strength calculations and actual freeboard and draught mark measurements (if the draught marks are provided).

6.7 The number of the test weight movements and, accordingly, of the heel angle measurements is to be such that of the total number of measurements, at least eight measurements meet the test quality criteria (see the Inclining Test Report). The end position of the test weights after all movements thereof is to be identical to their initial position.

6.8 When measuring the levers of the weight movements, only metal measuring tape is to be used; for the levers in excess of 20 m twenty-meter tape is to be used with transfer of same.

6.9 The liquid levels in the U-tubes (quadrants) are to be measured prior to movements of the test weights to an opposite side and after each movement.

The level measurements are to begin to be taken once the liquid oscillation swing has become not less than 20 mm, whereupon the level readings in both extreme positions (upper and lower) are to be recorded for at least three swings. Here, by the oscillation swing is meant the distance between two successive extreme positions (upper and lower) of the liquid levels in the U-tube.

After each measurement the observers at the U-tube (quadrant) stations are to report to the person in charge of the inclining test on completion of the measurements and inform of the results.

6.10 The accuracy of measurements made during the test is not to be lower than the values given below:

freeboard and draught, mm. 5
base length of U-tube, mm 10
liquid level in U-tube, mm 2
test weight mass, per cent. 1,0
position of test weight centre of mass, mm . . . 10
lever of test weight movement, mm 10
solid and liquid cargoes forming part of the deadweiht capacity:
mass, t 0,01

longitudinal centre of gravity, m 0,10
transverse and vertical centre of mass, m . . . 0,05
water density, per cent 0,1

7 INCLINING TEST REPORT

7.1 The inclining test is to be documented as a Report and Records Nos.1 — 10 which in conformity with the forms given in Appendices 2.1.1 to 2.1.10 are an integral part thereof.

The Report is to be signed by all members of the Inclining Test Commission, and the Records — by the responsible persons appointed by the Inclining Test Commission Chairman.

7.2 The Surveyor to the Register attending the test is to countersign the Inclining Test Report.

8 PROCESSING OF THE INCLINING TEST RESULTS

8.1 Measurements made during the test and the unit's technical documentation are to be taken as initial data in processing the inclining test results.

8.2 The displacement, coordinates of centre of buoyancy and transverse metacentric radius of the unit are to be determined from documentation which provides necessary accuracy of scales and measurements, accounts for the outstanding parts, etc. The hydrostatic curves are to be determined using a computer with required accuracy and with due account of the unit's trim if its value exceeds 0,005 its length (0,005L).

8.3 The arithmetic mean of the freeboard (draught) values before and after the inclining test, rounded off to 5 mm, is to be taken as their

final value (see Appendix 2.1.4).

In determination of the unit's underwater volume elements (displacement Δ, coordinates of centre of buoyancy X_c and Z_c) its sagging is to be accounted for by any sufficiently accurate method.

8.4 Not more than one measurement out of eight measurements referred to in 6.7 may be excluded from the calculation. A great number of measurements may be excluded only in well-grounded cases, on agreement with the Register, otherwise the inclining test is to be considered as unsatisfactory and is to be repeated.

Appendix 2.1

INCLINING TEST REPORT

________________________ " _____ "______________200 __

(test site)

1 Unit

Name, hull number ______________________________________

Purpose ______________________________________

Builder, building year ______________________________________

Owner ______________________________________

Principal dimensions (design) actual:

length *L* (__________) ______________________ m

breadth *B* (__________) ______________________ m

depth *D* (__________) ______________________ m

(See Record of acceptance of the unit's principal dimensions — Appendix 2.1.1 to the Inclining Test Report).

2 Arrangements for the inclining test

Inclining test objective ______________________________________

____

The inclining test was conducted by the inclining test commission set up to consist of:

Chairman ______________________________________

(position, full name)

members ______________________________________

(position, full name)

____

____

The results of the commission's activities were presented in the appropriate Records — Appendices ______________

________________________________ to the Inclining Test Report.

The inclining test was attended by the Surveyor to the Register ________________________________

(position, full name)

The inclining test was performed at ______________________________________

(indicate location where the test was performed)

____

____

Time of the inclining test:

commencement: ______________ h ________________ min "____"_______________200 __

completion: ______________ h ________________ min "____"_______________200 __

The inclining test was conducted in conformity with ______________________________________

____

(indicate guidance document, deviations therefrom)

____

____

3 Inclining test conditions

Wind velocity_______________________m/s

(Detailed data on wind are given in Appendix 2.1.2 to the Inclining Test Report)

Current velocity______________________m/s

Water surface condition____

Water density (see Appendix 2.1.2 to the Inclining Test Report) ρ_l _______________________ t/m^3

Water depth under the unit's bottom_____________________m

Air temperature ____________________________°C

Precipitation____

Ice conditions____

(size of a lane and method to break it out)

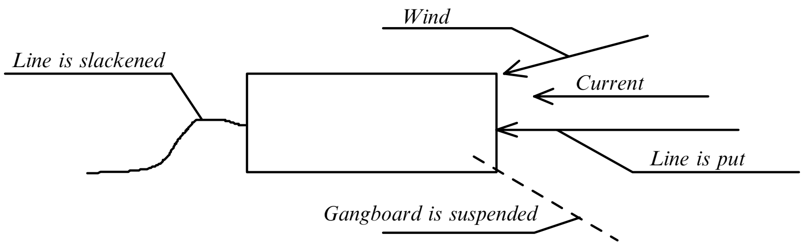
____

____

(no contact with ice, etc)

4 Preparations for the inclining test

The unit is ready for the inclining test (see Appendices 2.1.6 — 2.1.10 to the Inclining Test Report)



Sketch showing position of the unit

Initial heel of the unit ___________________________deg.

All foreign objects, debris and snow were removed from the unit.

External and internal surfaces of the unit, including those of the underwater body are free of icing.

All missing and surplus loads according to Table 1 (see Appendices 2.1.3, 2.1.7 to 2.1.9 to the Inclining Test Report) are taken into account.

Table 1

Missing and surplus loads during the inclining test

Loads including liquid loads, per cent of the unit's displacement during test Δ_{tl}	Mass, t	Levers, m			Moments, tm		
		X	Y	Z	M_X	M_Y	M_Z
Surplus loads; _______________ % of Δ_{tl} (sum from Appendices________________________) Missing loads; _______________ % Δ_{tl} (sum from Appendices________________________)							

Effects of liquid cargo free surfaces, running machinery on the inclining test performance

____
(indicate the free surfaces and machinery)

____________________ were essentially eliminated.

Technical documentation listed in Table 2 was used for the test.

Table 2

List of technical documentation used

Document title	Document designation	Document developer

The unit is loaded with solid (water) ballast (to be filled in if the ballast is available)

____
(purpose of the ballast (righting, etc))
____
____
____,

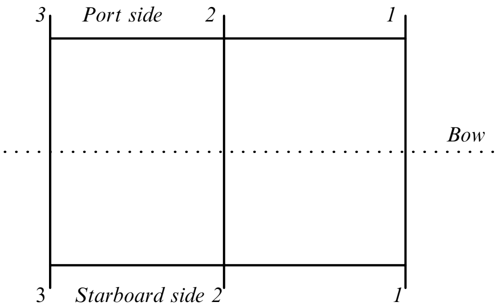
as indicated in Table 3.

Table 3

Data on ballast (righting, etc) loaded on board the unit

Position of solid (water) ballast	Mass, t	Coordinates of centre of mass, t		
		X	Y	Z
Grand total				

The transverse metacentric height during the test as per calculation ____________________ was ensured and equal to ________________



Sketch showing locations (sections) of freeboard (draught) measurements

5 The inclining test

5.1 Account is taken of the unit's freeboard (draught) values given in Table 4 on the basis of design data from the Record of freeboard (draught) measurements, see Appendix 2.1.4 to the Inclining Test Report.

Table 4

Design values of the unit's freeboard (draughts) during the inclining test

Measurement location (fixed transverse plane, draught mark, etc)	Freeboard, mm	Draught, mm

The unit's deflection during the inclining test is ________________________________ mm.

5.2 Based on the data of Table 4, the following draughts were obtained by calculation on

____
(document title)
____

at aft perpendicular (transom) ____________ m
at fore perpendicular (transom) ____________ m
at the unit's mid-length (midsection) ________ m
Initial heel of the unit
to __________ side ____________________ deg.
Initial trim
by __________ deg.(____________________ m)

For the unit's trim cited , the following data were obtained by calculation based on

____
(document title)

with regard to ______________________________
in ______________________________
(table, separate document)

volume displacement $\nabla =$ m^3,
weight displacement $\Delta = \rho_l \nabla =$ t,
coordinates of centre of buoyancy:
$X_C =$ ____________ m,
$Y_C =$ ____________ m,
$X_C =$ ____________ m;
transverse metacentric radius $r =$ __________ m.

5.3 During measurements of the heeling angles the mooring lines were slackened and nothing could restrict free rolling of the unit.

Account is taken of the heeling angle values given in Table 5, based on the data of level measurements in U-tubes (optical quadrants), see Appendix 2.1.5 to the Inclining Test Report.

Table 5

Design values of heeling angles during the inclining test

Number of successive inclination (measurement)	Position of test weights (side)	Heeling angle by U-tube (quadrant), rad. (deg)		Accepted value of heeling angle, rad. (deg)
		No. 1	No. 2	
1				
2				
...				
n-1				
n				

5.4 Calculation of metacentric height h_h under the test condition was made in Table 6 and hereafter, where the value of h_h was assumed as the mean of at least eight values of the metacentric height h_i obtained by individual measurements.

The mass of the heeling water ballast being transferred is______________t.

Lever of movement of the heeling water ballast being transferred is______________ m.

Heeling moment due to transfer of the heeling water ballast is__________tm.

In Table 6, increments in the heeling angles are used as their mean increments from Table 5.1 (5.2) of Appendix 2.1.5 for all the U-tubes (quadrants) used in the inclining test.

Table 6

Operation (measurement) No.	Increment in		$h_i = M_h/\Delta\varphi_h$, m	$h_i - h_h$, m	$(h_i - h_h)^2$, m^2
	heeling moment M_h, tf.m	heeling angle φ_h, rad.			
2					Measurement is precluded
3					
4					
5					
6					
7					
8					
9					
Sum			Σh_i	–	$\Sigma(h_i - h_h)^2$

From the data of Table 6:

$$h_k = \Sigma h_i / n, \text{ m}$$

where n = the number of sound measurements.

The inclining test was considered to be satisfactory performed, because:

.1 for each measurement the following condition was fulfilled

$$|h_i - h_k| \leqslant 2\sqrt{\Sigma(h_i - h_k)^2/(n-1)};$$

.2 probable error meets the condition

$$t_{an}\sqrt{\Sigma(h_i - h_k)^2/n(n-1)} \leqslant \begin{cases} 0{,}02(1 + \frac{3}{2}h_k), \text{ at } h_k \leqslant 2 \text{ m} \\ 0{,}04h_k, \text{ at } h_k > 2 \text{ m} \end{cases}$$

where t_{an} = a coefficient accepted in accordance with 1.5.11 from Table 1.5.11, Part IV "Stability" of the Rules for the Classification and Construction of Sea-Going Ships;

.3 the following condition is fulfilled:

$$t_{an}\sqrt{\Sigma(h_i - h_k)^2/n(n-1)} \leqslant 0{,}05h \text{ or } 0{,}10l_{max},$$

whichever is less, but not less than 4 cm

where l_{max} = the maximum arm of statical stability curve under the most unfavourable design loading condition as regards its value, m;

h = the corrected metacentric height under the most unfavourable loading condition as regards its value, m.

Where anyone condition: 5.4.1, 5.4.2, 5.4.3 is not met, the value of metacentric height h_k less the probable error of the test may be taken for calculations upon agreement with the Register:

$$h'_k = h_k - t_{an}\sqrt{\Sigma(h_i - h_k)^2/n(n-1)}.$$

Since during the test the water ballast tanks had free surfaces, the total correction for which was equal to $\sigma h = (\Sigma\rho_e \cdot i_x/\Delta)$, the metacentric height under test conditions was equal to $h_0 = h'_k + \delta h$.

5.5 Thus, the coordinates of centre of masses of the unit during inclining test were (at trim $\geqslant 0{,}005L$):

longitudinal centre of masses

$X_g = X_{c\psi} - (r_\psi - h_0)\sin\psi$;

transverse centre of masses $Y_g = h_0 \text{tg}\varphi$;

vertical centre of masses $Z_g = Z_{c\psi} + (r_\psi - h_0)\cos\psi$.

(The formulae are given with consideration for possible angles of heel φ and trim ψ).

The displacement Δ = _________ t (see 5.2).

5.6 Displacement and coordinates of centre of masses are given in Table 7.

Table 7

No	Elements of mass loading	Mass, t	Levers, m			Moments, tm		
			X	Y	Z	M_X	M_Y	M_Z
1	Unit under test conditions							
2	Surplus loads							
3	Missing loads							
Unit (1) – (2) + (3)								

6 Notes

At the discretion of the inclining test commission chairman.

7 Processing of test results

The results of the inclining test were processed by

____

____
(name of the firm)

The original materials of the inclining test are held by______________________________

____
(name of the holder)

Appendices 2.1.1 to 2.1.10 to the Inclining Test Report are an integral part______________

____
(name of the unit)

of the present Report on inclining of the unit

8 Conclusions

The inclining test was well performed.

Based on the test results the following actual data of the unit______________________________

____

____
(name of the unit)

are considered to be established:

displacement Δ_0 = ____________t;

vertical centre of masses Z_g = ______________m;

longitudinal centre of masses X_g = __________m;

transverse centre of masses Y_g = ____________m.

Inclining test commission chairman:

____

____

____
(signature, full name)

Members of the commission:

representative of the builder______________

representative of the designer______________

representative of the customer ______________

____
(signature, full name)

The inclining test was attended by the Surveyor to the Register______________________________

____

____
(signature, full name)

Appendix 2.1.1

RECORD OF ACCEPTANCE OF THE UNIT'S PRINCIPAL DIMENSIONS

"______"____________________ 200__ city ______________________

firm __________________

Principal dimensions of the unit____

(name, purpose)

were verified____

(place of building, assembling, mounting)

length L — with the help of ____
breadth B — with the help of ____
depth D — with the help of ____
The verification data are given in Table 1.1.

Table 1.1

Principal dimensions	As per design, m	Actual, m
Length Breadth Depth: port starboard		

The principal dimensions as per deviations from the drawing__________________________
are within tolerance.
Measurements were made by:____

(position, full name)

Appendix 2.1.2

RECORD
OF MEASUREMENTS OF WIND VELOCITY AND DIRECTION, WATER DENSITY AND UNIT'S POSITION DURING INCLINING TEST

Unit____ " ___ "__________________200__

(name)

The measurement data are given in Table 2.1.

Table 2.1

Measu-rement No	Wind velocity, m/s	Wind direction in respect to unit		Unit direction	Measurement time, Hr., min
		Angle, deg.	side (port, starboard)		
1 2 ... 9 10					

The wind direction was determined by the angle between centreline and velocity vector, considering from the bow to windward side.

Based on the samples taken from the depth of __________________ m,

the water density was_________________ t/m^3 at the temperature of ____________________ °C.

Measurements were made by:____

(position, full name)

____

____

Appendix 2.1.3

RECORD
OF SURPLUS (MISSING) LOADS

Unit____ " ___ "_________________200__
(name)

All loads on the unit which are surplus (missing) in relation to the mass loading corresponding to the unit condition at the time of the inclining test are given in Table 3.1 (3.2)

Table 3.1 (3.2)

Load	Mass, t	Levers, m			Moments, tm		
		X	Y	Z	M_X	M_Y	M_Z
Liquid cargo remains in hull*							
Liquid cargo in machinery, apparatus, etc. to keep them running**							

* To be included into the Records of surplus (missing) loads according to data of Appendix 2.2.7.
** Design data are to be indicated.

Record was prepared by: ______________________________________
(position, full name)

____

____

Appendix 2.1.4

RECORD
OF THE UNIT'S FREEBOARD (DRAUGHT) MEASUREMENTS

Unit____ " ___ "________________200__
(name)

1. Measurements were taken with the use of _________________________ and are given in Table 4.1.
(name of devices)

Table 4.1

Measurement location (Section) acc.to Fig. 2	Time of measurement: before test, after test	Reference level: deck, (bulwark,), draught mark	Freeboard; draught mark, mm	Measurement from deck, draught mark		Value as obtained by measurement, mm		Deck stringer, keel thickness, mm	Theoretical value, mm		Theoretical, (mean) value, mm	Design value, mm
				Port	Stbd	Port (4)-(5)	Stbd (4)-(6)		Port	Stbd		
1	2	3	4	5	6	7	8	9	10	11	12	13
Freeboard												
Section 1-1	Before/after	Upper deck		$\frac{2290}{2280}$	$\frac{2270}{2240}$			20	$\frac{2270}{2260}$	$\frac{2260}{2220}$	$\frac{2265}{2240}$	2252
Section 2-2	Before/after	Ditto										
Section 3-3	Before/after	Ditto										
Draught												
Section 1-1	Before/after	Mark 60	6000	$\frac{200}{220}$	$\frac{220}{240}$	$\frac{5800}{5780}$	$\frac{5780}{5760}$	20	$\frac{5780}{5760}$	$\frac{5760}{5740}$	$\frac{5770}{5740}$	5760
Section 2-2	Before/after	Mark 62	6200									
Section 3-3	Before/after	Mark 64	6400									

(The numerical values are given in the Table as an example).

2. The design values of freeboard (draughts) were entered on__________________________________
(drawing title)

3. According to the measurements made the module hull sagged (did not sag) with a deflection of ______ mm.

Record was prepared by____
(position, full name)

____

____

Appendix 2.1.5

RECORD
OF U-TUBE LEVEL DEVIATION AND UNIT'S INCLINATION ANGLE MEASUREMENTS

Unit____ " ___ "_________________200__
(name)

Table 5.1

Heel measurements							
Operation (measurement) No.	Test-weight position (side)	Level measurement, mm				Heel angle increment, Rad.(deg)	
		U-tube No.1 Base length __________ mm		U-tube No.2 Base length __________ mm		U-tube No.1	U-tube No.2
		Stbd	Port	Stbd	Port		
1 2 . . . 9 10							
Trim measurements							
Operation (measurement) No.	Test-weight position (side)	Level measurement, mm				Trim angle increment, rad.(deg)	
		U-tube No.3 Base length __________ mm		U-tube No.4 Base length __________ mm		U-tube No.3	U-tube No.4
		Stbd	Port	Stbd	Port		
1 2 . . . 9 10							

(When determining the unit's inclination angles with the use of optical quadrants tables which look like Table 5.2 are to be used).

Table 5.2

Operation (measurement) No.	Test-weight position (side)	Quadrant No.			Mean value of angle, deg.	Angle of heel, deg.	Heel angle increment	
		Angle of heel, deg.						
		Measurement 1	Measurement 2	Measurement 3			deg.	rad.
1 2 . . . 9 10								

Account is to be taken of the increments in the unit's inclination angles obtained from the data of all quadrants used for the inclination kind involved (heel, trim).

Measurements were made by ____
(position, full name)

Appendix 2.1.6

RECORD
OF VERIFICATION OF AVAILABILITY OF COMPARTMENTS, LIQUID CARGO TANKS, CANISTERS AND COFFERDAMS FOR THE INCLINATION TEST

Unit____ " ___ "_________________200__

(name)

The inclining test commission verified the condition of compartments, liquid cargo tanks, canisters and cofferdams of the unit and found out that by the commencement of the test:

1) the compartments, tanks and cofferdams were drained, except for the tanks in which, on the commission's decision, liquid cargoes were left and which were pressed up (see Appendix 2.1.7 to the Inclining Test Report);

____

____

____

(special notes)

2) valves of the filling and daily service piping were shut off and sealed;

3) mass of the liquids in tanks was accounted for in the records of surplus (missing) loads.

Chairman of the commission ____

(signature, full name)

Members of the commission ____

(signature, full name)

Appendix 2.1.7

REPORT
OF VERIFICATION OF CONDITION OF COMPARTMENTS, LIQUID CARGO TANKS, CANISTERS AND COFFERDAMS

Unit____ "___"_________________200__
(name)

Members of the inclining test commission ______________________________________
(full name)

____

____

verified carefully the liquid cargo tanks, including small daily service and other tanks and canisters, etc. Results of the verification are given in Table 7.1.

Table 7.1

Tank	Where water ballast is available							Filling pattern	Components of mass loading
	Mass, t	Levers, m			Moments, tm				
		X	Y	Z	M_X	M_Y	M_Z		
Fresh water No Lubricating oil Water ballast No. Fuel oil No.									Surplus load Missing load Surplus load Missing load
Surplus loads in total									
Missing loads in total									

Water ballast of ________ t was taken aboard in order to impart to the unit a draught of __________ m, corresponding to the calculation.

Tanks Nos. ___________________ were pressed up until liquid appeared in air pipes, with a previous time delay of ________________h.

(Included in Table 7.1 are all tanks, compartments and cofferdams available on the unit, which may contain liquid cargoes, regardless of their degree of filling. Column "Filling pattern" is used to note that the space was pressed up, filled completely, filled partly, contains liquid cargo remains, empty).

Members of the inclining test commission:
Signatures ____
(full name)

____

Appendix 2.1.8

RECORD
OF DETERMINATION OF HEELING WATER BALLAST MASS
(model form)

Unit____ "___"_________________200__
(name)

Mass of the heeling water ballast was determined by calculation-based method (with the use of measuring vessels).

Schemes were given for the forms and volumes of ballast (and other) tanks or compartments (subsequently referred to as "tanks") used for heeling ballast. The schemes were constructed in three projections (or in axonometry) with indication of all geometric dimensions, arrangement of the metal framework and equipment in the tanks, references to the final plans of tanks (compartments) were made.

Determination of the volumes and volume centres of gravity of the tanks, as well as of the levels and store amount therein was carried out in tables (or by other ways); free surfaces and their effect on the inclining test performance were recorded.

Strict control was exercised over the condition of the heeling water ballast free surfaces in tanks after each transfer of the heeling ballast (or over the absence of free surfaces), to which effect relevant entries were made in the Record. (Form and number of tables, figures describing this process — at the discretion of the inclining test commission).

The free surfaces of the heeling water ballast in all tanks at all inclinations were of a regular rectangular shape.

During transfer of the heeling water ballast its upper and lower levels in tanks were within wall-sided portion of the tanks and were marked by clearly distinguishable lines (marks) on the battens fitted in the tank corners and accessible for observation through the manholes (hatches) with the help of an effective portable lighting (or by other reliable means).

Corrections for the free surfaces in the water ballast tanks were accounted for in determination of the initial transverse metacentric height from the inclining test data.

Procedures for preparation
of the present Record were executed by____
(position, full name)

Appendix 2.1.9

RECORD
OF STATIONING OF THE PARTICIPANTS IN THE INCLINING TEST ON BOARD THE UNIT

Unit____ " ___ "_________________200__
(name)

The Record is given in Table 9.1.

Table 9.1

Space (station)	Number of persons	Mass, t	Levers, m			Moments, tm		
			X	Y	Z	M_X	M_Y	M_Z
Grand total								

Record was prepared by:_______________________________________
(position, full name)

____

____

____

Appendix 2.1.10

RECORD OF MEASUREMENT OF U-TUBE BASE LENGTH, VERIFICATION OF POSITIONING OF MEASURING RULES (BATTENS) AND OPTICAL QUADRANTS

Unit____ " ___ "_________________200__
(name)

Base lengths of the U-tubes were measured by a steel measuring rule of ___________m long between glass tubes attached to the measuring rules (battens) at a height of __________m above the upper deck of the unit.

It was found out through the verification that:

base length of the U-tubes was of_________________m;

measuring rules (battens) were so attached to the unit's hull that they do not shift when in use during the test;

rules (battens) were positioned normally to the base plane of the unit;

positioning of the optical quadrants was verified against the hull reference lines (verification bases) situated on ____________________

The results of the measurements are given in Table 10.1.

Table 10.1

U-tube (quadrant) No	U-tube (quadrant) position	U-tube base length, mm			Note
		Measurement 1	Measurement 2	Design value	

Measurements were made by____
(full name)

Position ____

APPENDIX 3

PROCEDURE FOR CALCULATION OF WIND PRESSURE ACTING ON UNIT FOR ALL POSSIBLE WIND DIRECTIONS

This calculation procedure may be applied for determination of wind pressures acting on semi-submersible drilling units with rectangular-shaped upper hull, stability columns of different configuration and helideck outside the said hull at arbitrary angles of wind action.

In order to determine the wind pressure in case of arbitrary wind direction, it is necessary to obtain the wind pressures F_1, F_2, F_3, F_4 with the air flow normal to the midship section and the centre line of the unit (Fig. 3.1).

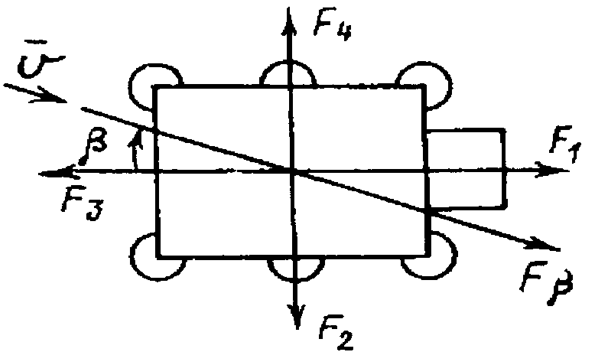


Fig. 3.1

The values of wind pressure F_1, F_2, F_3, F_4 are to be calculated according to 2.4.2 of the present Part.

With the change of wind direction F_β from 0 to $\pi/2$ in each of the quarters the intermediate values of wind pressure F_β, deg., are to be determined using the empirical dependence:

$$F_\beta = F_i \cos^2\beta + F_{i+1}\sin^2\beta + \frac{1}{2}|\delta F| ctg 2\theta \sin 2\beta \qquad (3.1)$$

where: $\beta (0 \leqslant \beta \leqslant \pi/2)$ = the angle to be determined on the basis of wind direction at which F_i was calculated; $i = 1,2,3,4$ (when F_β is determined in the last quarter $F_i = F_4$; $F_{i+1} = F$);

$\delta F = F_i - F_{i+1}$ = the difference in wind pressure in i-th and $(i+1)$-th positions of the unit;

$\theta = 57{,}3k\sqrt{|\delta F|/(F_i + F_{i+1})}$ = the angle of displacement defining the value and position of the wind pressure maximum.

Factor $k = 0{,}66$ rad. is obtained from wind tunnel experiment on the unit models.

Where $|\Delta F|/(F_i + F_{i+1})100 > 7$ %, the wind pressure is to be obtained using the formula:

$$F_\beta = \frac{F_i + F_{i+1}}{2}(1 + 0{,}25|\sin 2\beta|). \qquad (3.2)$$

The maximum value of wind pressure F_β obtained by the Formula (3.1) will be:

$$F_{max} = \frac{F_i + F_{i+1}}{2} + \frac{1}{2}\frac{|\delta F|}{\sin 2\theta} \qquad (3.3)$$

$$\text{with } \beta = \begin{cases} \pi/4 + \theta, \text{ если } F_i < F_{i+1}; \\ \pi/4 - \theta, \text{ если } F_i > F_{i+1}. \end{cases}$$

Where $|\delta F|/(F_i + F_{i+1})100 < 7$ %, the maximum value of wind pressure with $\beta = \pi/4$ will be

$$F_{max} = 1{,}25\,\frac{F_i + F_{i+1}}{2}\,. \qquad (3.4)$$

APPENDIX 4

PROCEDURE FOR CALCULATION OF WIND HEELING MOMENT FOR SEMI-SUBMERSIBLE AND SUBMERSIBLE UNITS WITH RECTANGULAR UPPER HULL

This calculation procedure takes into consideration the effect of vertical forces arising in the upper hull and helideck (outside thereof) in case of unit inclinations and shielding effect of the water surface on the heeling moment.

The procedure may be applied for determining the wind heeling moment of a semi-submersible or submersible unit with rectangular-shaped upper hull in pitching and rolling of the unit.

When a unit is inclined, the wind pressure acting on its components other than upper hull and helideck is considered proportional to the cosine of angle of inclination.

Additional horizontal forces caused by a lifting force acting on the hull and helideck of the unit when it is inclined are to be determined by the formula

$$\Delta F = \frac{\rho_A V_w^2}{2}\, n_k (C_{Zk} S_k + C_{Zh.d.} S_{h.d.}) tg\alpha \qquad (4.1)$$

where V_w = the mean velocity of steady wind flow at a height of 10 m above the sea level;

n_k = the coefficient of velocity head increase over the height Z_h equal to the distance of the upper hull centre from the sea surface;

C_{zk} = the coefficient of lifting force of the upper hull at the arbitrary angle of unit inclination which is to be taken from Figs. 4.1 to 4.3 depending on the relative height of the upper hull projected area centre above the water surface:

$$\bar{z} = z_k / L_k;$$

L_k = dimension of the upper hull in the direction of wind flow;

$C_{zh.d}$ = the coefficient of lifting force of the helideck at an arbitrary angle of unit inclination which is to be taken from Fig. 4.2 for the height $\bar{z} = \infty$ (unlimited flow);

S_k, $S_{h.d.}$ = areas of the upper deck and helideck in plan, m^2 (these areas are assumed for calculation, since the values of coefficients of lifting force and heeling moment shown in Figs. 4.1 to 4.6 are obtained by dividing the forces and moments by the area in plan);

α = the angle of unit inclination (i.e. the angle of heel φ or trim ψ), deg.

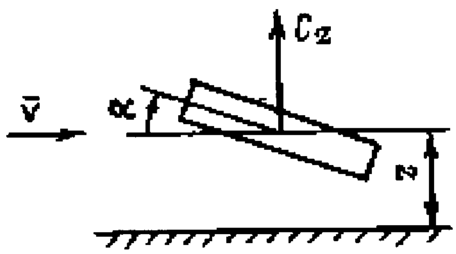
The wind pressure in case of unit inclination caused by the horizontal components of wind forces is to be determined by the formula

$$F = \frac{\rho_A V_w^2}{2} \left[(\cos\alpha \sum_j C_{Sj} C_{Hj} A_{Vj} + n_k tg\alpha (C_{Zk} S_k + C_{Zh.d.} S_{h.d.})\right] \quad (4.2)$$

where A_{Wj} = the windage area of the j-th windage area component;

C_{Sj} = the shape coefficient of the j-th windage area component;

C_{Hj} = the height coefficient of the j-th windage area component.



$\lambda = B_k / L_k = 0,5$

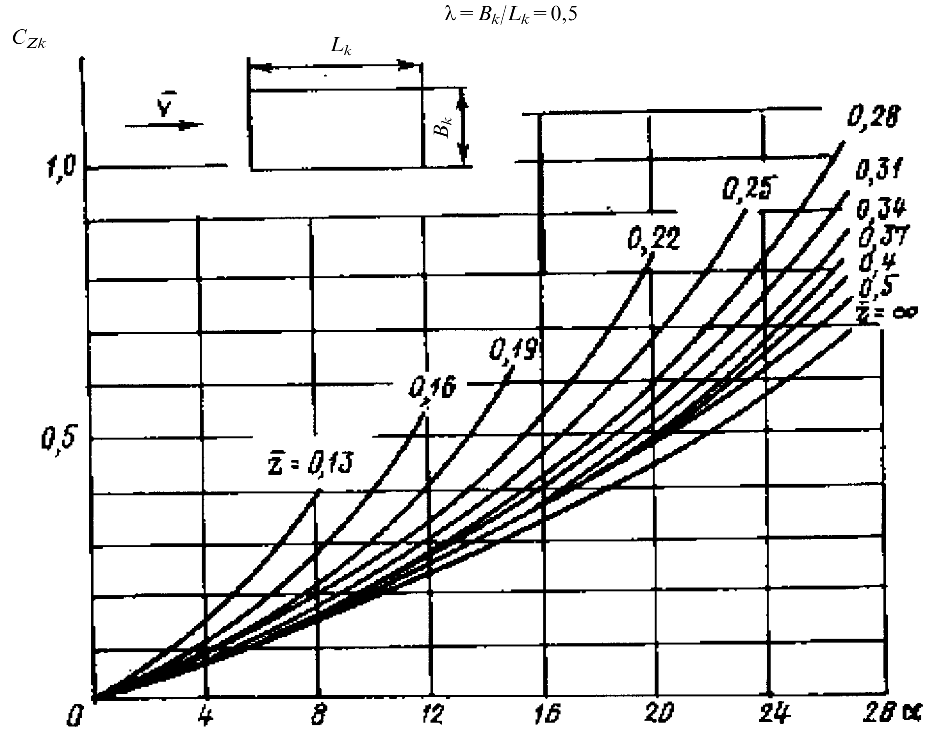


Fig. 4.1

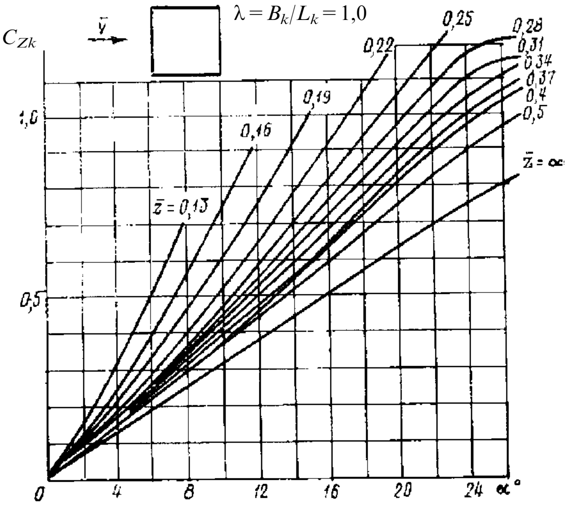


Fig. 4.2

The wind heeling moment relative to the centre of application of hydrodynamical forces is to be calculated by the formula

$$M = M_{H.F.} + M_{V.F} + FZ_{\omega} \qquad (4.3)$$

where $M_{H.F.}$ = the moment of horizontal forces relative to the origin of the wind coordinate system 0XYZ, which is the point of intersection of the vertical axis Z with the waterline plane (Fig. 4.7, point 0);

$M_{V.F.}$ = the moment of vertical forces relative to the point 0, the origin of the wind coordinate system 0XYZ;

F = the wind pressure determined by the Formula (4.2);

Z_{ω} = the distance from the waterline to the centre of application of the resultant of hydrodynamical forces to be determined according to 2.4.3 of the present Part.

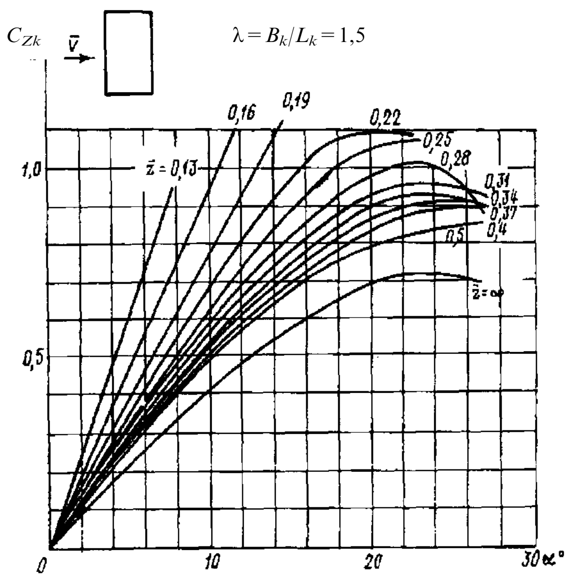


Fig. 4.3

The horizontal force moment is to be determined by the formula:

$$M_{H.F.} = \frac{\rho_A V_w^2}{2} [\cos\alpha \sum_j C_{Sj} C_{Hj} A_{wj} Z_j + n_k tg\alpha (C_{Zk} S_k z_k + C_{Zh.d.} S_{h.d.} z_{h.d.})] \qquad (4.4)$$

where $Z_{h.d.}$ = the distance from centre of the helideck.(Fig. 4.7) to the sea surface, m.

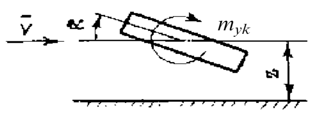
The vertical force moment is to be determined by the formula

$$M_{V.F.} = \frac{\rho_A V_w^2}{2} (m_{yk} S_k L_k + C_{Zh.d.} S_{h.d.} x_{h.d.})] \qquad (4.5)$$

where m_{yk} = the coefficient of vertical force moment arising on the hull to be determined using the relationships shown in Figs. 4.5 to 4.7;

z_j = the distance from windage area centre of the j-th element to the sea surface, m;

$x_{h.d.}$ = the arm of vertical force arising at the helideck, m (assumed equal to the value of projection on the horizontal plane of the distance from the helideck centre to the upper hull centre (see Fig. 4.7).



$\lambda = B_k/L_k = 0,5$

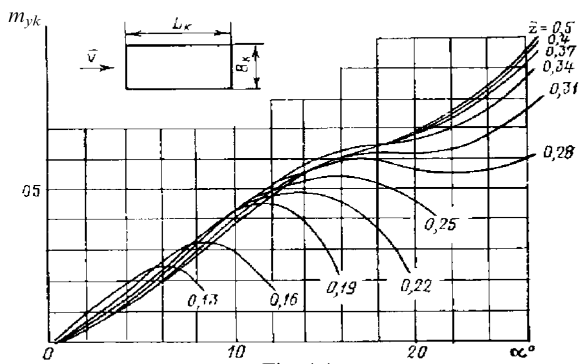


Fig. 4.4

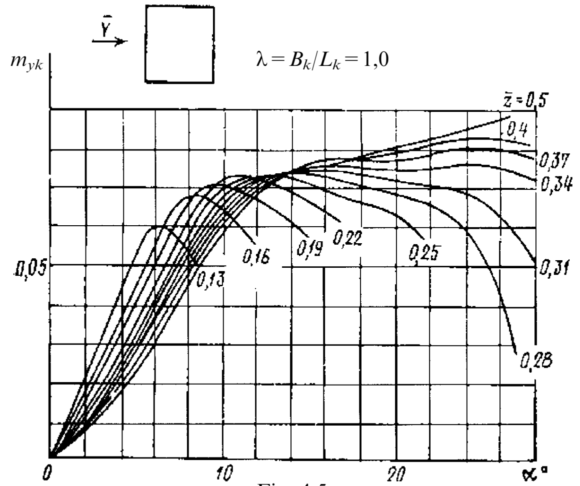


Fig. 4.5

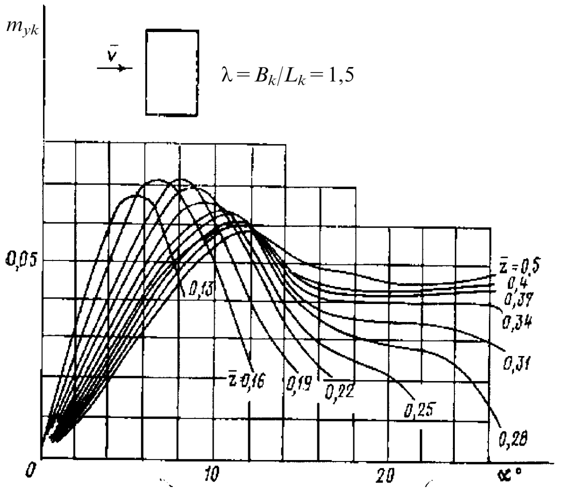


Fig. 4.6

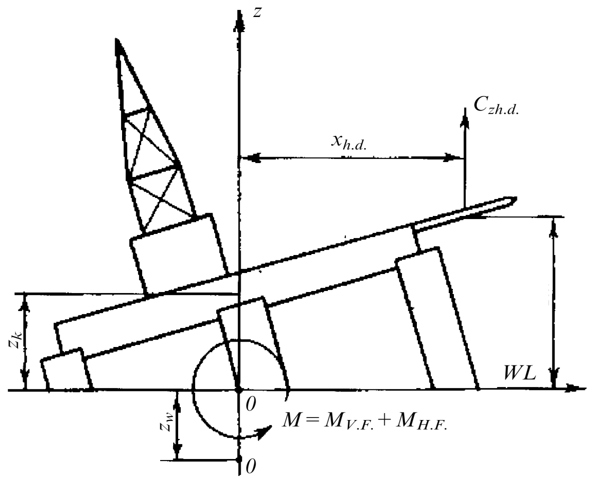


Fig. 4.7

The Formula (4.5) is used for the heel and trim of the unit if the helideck is on the windward side. If the helideck is on lee side , the effect of the vertical force arising at the helideck is not to be taken into account, since it is negligible.

The values of aerodynamical coefficients C_{zk} and m_{yk} for hulls with intermediate values of elongation $\lambda = B_k/L_k$ are to be determined by interpolation with dependencies $C_z = f(\lambda)$ and $m_{yk} = f(\lambda)$ being constructed for $\alpha = \text{const}$ and $\bar{z} = \text{const}$.

The values of aerodynamical coefficients C_{zk} and m_{yk} for intermediate values of relative heights are to be determined by interpolation $C_z = f(\bar{z})$ and $m_{yk} = f(\bar{z})$ being constructed for $\lambda = \text{const}$ and $\alpha = \text{const}$.

APPENDIX 5

VALUES OF EXTREME WIND VELOCITIES AND WAVE HEIGHTS POSSIBLE ONCE EVERY 50/100 YEARS

Table 5.1

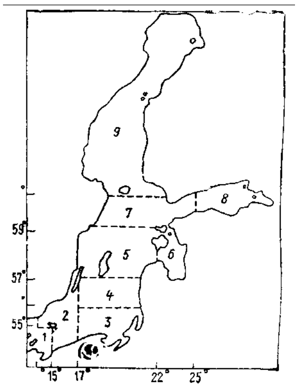
Area	Average wind velocity (averaging period 10 min), $\bar{\omega}_{50/100}$, m/s	Wave height with 3 per cent probability of exceeding $h_{50/100}$, m	Map
For Baltic Sea			
1	34/36	13/14	
2	34/36	13/14,5	
3	34/36	15/16	
4	36/38	15/16	
5	37/40	13/15	
6	32/34	9/10	
7	35/37	14/16	
8	34/36	9/10	
9	35/37	9/11	
Entire water area	37/40	15/16	

Table 5.2

Area	Average wind velocity (averaging period 10 min), $\bar{\omega}_{50/100}$, m/s	Wave height with 3 per cent probability of exceeding $h_{50/100}$, m
	For Barents Sea	
1	Is not RF zone	
2	Ditto	
3	No data available	18/20
4	Ditto	18/20
5	Is not RF zone	
6	31-33/33-35	17/18
7	31-33/33-35	15/16
8	31-45/33-36	13/15
9	31-33/33-35	14/16
10	32-45/33-46	11/12
11	31/33	9/10
Entire water area:		
up to 75°N	45/46	17/18
Above 75°N	No data available	18/20

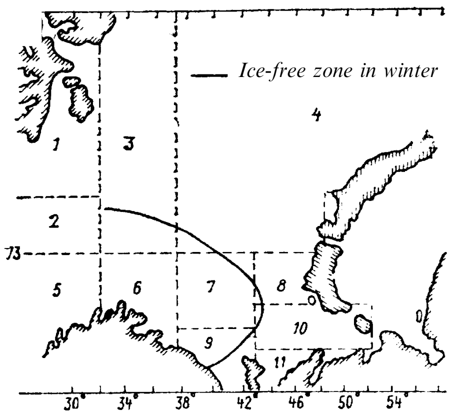


Table 5.3

Area	Average wind velocity (averaging period 10 min), $\bar{\omega}_{50/100}$, m/s	Wave height with 3 per cent probability of exceeding $h_{50/100}$, m
	For Caspian Sea	
1	34/36	8,5/9,5
2	34/38	13/14
3	34/36	12/13
Entire water area:	36/38	13/14

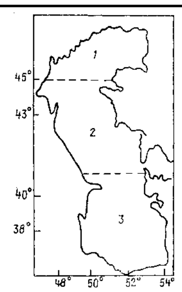


Table 5.4

Area	Average wind velocity (averaging period 10 min), $\bar{\omega}_{50/100}$, m/s	Wave height with 3 per cent probability of exceeding $h_{50/100}$, m
	For Okhotsk Sea	
1 S, D	No data available	No data available
2 S, D	44/46	17/19
3 S	44/46	13/15
4 D	No data available	18/20
5 S, D	39/41	18/19
6 S	40/42	10/11
7 D	No data available	17/19
8 S, D	44/46	12/13
9	No data available	13/14
Entire water area: in shelf zohes	44/46	17/19
In the middle part (deep-sea zone)	No data available	18/20

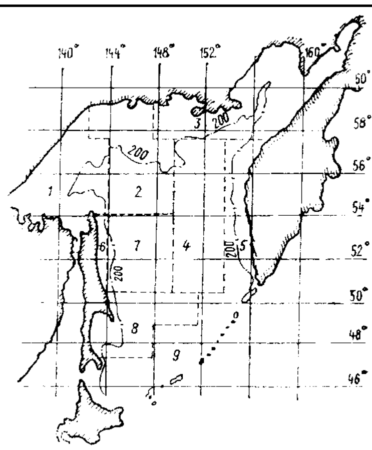
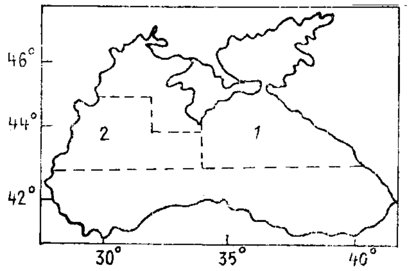


Table 5.5

Area	Average wind velocity (averaging period 10 min), $\bar{\omega}_{50/100}$, m/s	Wave height with 3 per cent probability of exceeding $h_{50/100}$, m	Map
	For Black Sea		
1	37/40	12,5/14,5	
2	36/39	13/14,5	
Entire water area:	37/40	13/14,5	

N o t e s : 1. Data on the wind and waves are given for the winter season and are to be considered as design data. Parameters of the transformed waves in shallow-water zones are to be recalculated on the basis of the deep water data.

2. Symbols: S means shelf zone, D means deep-sea zone.

In order to enhance the operational capabilities of the unit with due account of the seasons, it is necessary to use data of the Goskomgidromet, which account for seasonal fluctuation and zoning. When no such data are available, reduction coefficients given in Table 5.6 may be used.

Table 5.6

Hydrometeorological conditions	Season			
	Winter	Spring	Summer	Autumn
Wind	1,0	0,9	0,8	0,95
Waves	1,0	0,95	0,75	0,90

PART V. SUBDIVISION

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part apply to:

all types of self-elevating and submersible MODU and FOP while being afloat in transit;

semi-submersible MODU in transit and in operation;

FOP modules afloat in transit with more than 12 persons on board.

The above floating structures are subsequently referred to as "units".

1.1.2 Drilling ships are to meet the requirements specified in Part V "Subdivision" of Rules for the Classification and Construction of Sea-Going Ships, when any compartment is damaged unless the shipowner imposes more stringent requirements, and, additionally, the requirements of 2.5.5.

1.1.3 The need to follow the requirements of this Part where FOP modules not listed under 1.1.1 are concerned is established by the Register with due regard for their displacement and the equipment installed.

1.1.4 When the Register does not insist on fulfillment of the requirements of this Part but, according to the FOP owner's or builder's option, provision is made for ensuring satisfactory damage trim and stability of FOP modules, it is recommended to follow the provisions of in flooding of given compartments or groups of adjacent compartments.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 The definitions and explanations relating to the general terminology are specified in Part I "Classification" of MODU/FOP Rules.

For the purpose of this Part the following definitions have been adopted.

Damage waterline is the waterline of a damaged unit after flooding of one or several adjacent compartments.

Watertightness means the capability of a structure to prevent water penetration in any direction under the water head the structure is designed for.

Length of unit (L) means the hull length measured at the level of the waterline corresponding to the maximum draught of the unit afloat in transit.

Draught d means a vertical distance measured at the midpoint of the appropriate length from the top of the plate keel or from the point where the inner surface of the shell (outer surface for units with a non-metal shell) abuts upon the bar keel, up to the relevant waterline of the unit.

Compartment means the part of the internal hull space bounded by shell plating, watertight bulkheads, decks, platforms, stringers and floors. As applied to stability columns, compartment means the part of the internal column space bounded by shell plating, watertight vertical bulkheads and horizontal platforms along its perimeter.

Permeability of space μ is the ratio of the volume that may be filled with water in full flooding of the space to the total theoretical volume of the space.

Weathertightness means that in any sea conditions water will not penetrate into the unit.

Downflooding means any flooding of any intact buoyant part of the unit's hull through the openings located below the damage waterline and which cannot be closed watertight, or which are required for operational reasons to be kept open.

Equalization of unit is the process of eliminating or reducing heel and/or trim.

Angle of inclination is the angle between the vertical and the line of intersection of the unit's center and midstation planes.

The tangent of the angle of inclination φ is determined by the formula

$$tg(\varphi) = (tg^2\theta + tg^2\ \psi)^{1/2}$$

where θ = angle of heel;
ψ = angle of trim.

Breadth of unit's hull (B) means the extreme moulded breadth of the unit's hull measured at the midpoint of its length L at the level of or below the waterline in transit.

In all design flooding conditions only one damage is assumed and only one free surface of the outside water that penetrates the compartment after an accident is taken into account. The damage therewith is assumed to be shaped as a rectangular parallelepiped.

1.3 SCOPE OF SUPERVISION

1.3.1 The general provisions pertaining to the procedure of classification, supervision during construction, classification surveys, as well as the requirements for technical documentation to be submitted for examination and approval by the Register are specified in Part I "Classification" of MODU/FOP Rules.

1.3.2 For every unit covered by the requirements of this Part, the Register carries out:

.1 verification of the compliance of structural arrangements concerning subdivision against the requirements specified in Part II "Hull", Part III "Equipment, Arrangements and Outfit of MODU/FOP" and Part VII "Machinery Installations and Machinery" of MODU/FOP Rules;

.2 examination and approval of Information on Damage Trim and Stability;

.3 examination and approval of the relevant software if provision is made for use of a shipboard computer to evaluate damage stability.

1.4 GENERAL TECHNICAL REQUIREMENTS

1.4.1 Calculating damage trim and stability the effect of anchor, mooring, towing and other restraints is to be taken into account if it may cause serious consequences. The impact of the like restraints is to be assessed according to the procedure or calculation program approved by the Register.

1.4.2 Calculating the initial metacentric height and plotting static stability curves for a damaged unit, the free surface corrections for liquids in intact tanks are to be regarded in a way similar to stability calculations of the intact unit in accordance with Part IV "Stability" of MODU/FOP Rules.

1.4.3 Plotting static stability curves for a damaged unit, enclosed superstructures, deckhouses, deck cargo, as well as angles of flooding through the openings assumed as open are to be taken into account in the same manner as in the case of plotting the curves for an intact unit in accordance with Part IV "Stability" of MODU/FOP Rules.

Damaged superstructures and deckhouses may be regarded only with the permeability specified in 2.3 or not regarded at all. The openings inside the above spaces used for access to non-flooded spaces are assumed open for ingress of water at appropriate angles of inclination unless they are provided with standard closing weathertight devices.

1.4.4 All units are to be provided with Information on Damage Trim and Stability approved by the Register. This document is to allow the Master of a unit to take into account the requirements associated with subdivision and to assess the condition of the damaged unit prior to taking appropriate measures for survival of the damaged unit.

The Information is to include the following data:

.1 data on the unit, schematic diagrams of its inboard profile and sectional view, of deck and platform plans, of typical cross-sections of hulls and stability columns with indication of watertight bulkheads, enclosures, platforms with openings therein, the type of closure of these openings. The openings that are open during drilling and must be closed watertight in transit are to be expressly specified. The diagrams of systems used in damage control of the unit are also to be presented;

.2 data essential for maintaining stability, trim of an intact unit, and sufficient for withstanding, in accordance with the requirements of this Part, the most dangerous design damage;

.3 the summary of the results of damaged unit condition calculations which includes parameters of an initial and damage draught, heel and trim, a metacentric height and stability curves prior to and after taking measures for equalization, as well as recommended measures and the time of equalization;

.4 other data on structural provision of subdivision, on the use of cross-flooding arrangements and emergency means, as well as potential consequences of flooding due to particular features of a given unit, recommended and prohibited actions for the crew in service and in accidents with the unit associated with compartments flooding.

1.4.5 Information on Damage Trim and Stability is to be compiled on the basis of unit's inclining test results and the data contained in Information on Stability.

The procedure for extending the validity of Information from one unit to another of the same series of construction is similar to that applied for Information on Stability specified in Part IV "Stability" of MODU/FOP Rules.

1.4.6 In time periods not exceeding 5 years, Information on Damage Trim and Stability of an existing semi-submersible MODU is to be either confirmed or updated with due regard for the change of a light displacement and/or the results of the unit's in-service inclining test conducted.

1.4.7 The diagrams showing the boundaries of watertight compartments, arrangement of openings leading to these compartments and their means of closing with indication of control stations of these means, as well as arrangements for equalizing heel and trim due to compartments flooding are to be exhibited in every unit.

1.4.8 The shipboard computer is recommended for use to estimate damage trim and stability. In this case, the relevant software is to have the Register permit.

Electronic information does not substitute Information on Damage Trim and Stability.

1.5 GENERAL REQUIREMENTS FOR SUBDIVISION

1.5.1 Subdivision of units listed in 1.1.1 is considered to be satisfactory if damage trim and stability meet the requirements of Section 2.

1.5.2 Depending on the unit's type the requirements of Section 2 are to be fulfilled in the following cases:

.1 in transit — for self-elevating, submersible and semi-submersible MODU and FOP and their modules, and for drilling ships;

.2 in operation afloat — for semi-submersible MODU and drilling ships.

1.5.3 The alternative requirements for subdivision and damage buoyancy and stability may be used if the presented evidence approved by the Register confirms that the level of damaged unit safety is not lower than that provided for in Part V "Stability" of Rules for the Classification and Construction of Sea-Going Ships.

2 TRIM AND STABILITY OF DAMAGED UNIT

2.1 GENERAL

2.1.1 Trim and stability of an intact unit in all operational loading conditions corresponding to the unit's intended purpose (without regard for icing) are to be sufficient to ensure fulfillment of the requirements for damage trim and stability of a damaged unit.

2.1.2 The requirements for unit's damage trim and stability are considered to have been fulfilled if, under damages specified in 2.2 with the number of flooded compartments mentioned in 2.4, at the permeability determined according to 2.3, the calculations made in compliance with the conditions in 2.1.3 to 2.1.7 indicate that the proper requirements specified in 2.5 to 2.7 are complied with.

2.1.3 The calculations confirming fulfillment of the requirements in 2.5 to 2.7 for damage trim and stability of a damaged unit are to be made for such a number of the worst, with reference to trim and stability, loading conditions (within the draught up to the deepest subdivision waterline and cargo distribution stipulated by the design), such location and extent of a damage determined in accordance with 2.2 that, proceeding from these calculations, one could be assured that in all other cases the damaged unit condition as regards damage stability, the residual freeboard, elevation above the damage waterline of the openings through which progressive flooding of the unit is possible, and the angles of heel, will be more favourable.

2.1.4 Where the distance between two adjacent main transverse bulkheads is less than the design damage extent lengthwise, an appropriate compartment is, at the designer's discretion, to be added to one of the adjacent compartments when checking damage trim and stability.

The forepeak and afterpeak are considered to be independent regardless of their extent.

2.1.5 Where the step of a bulkhead is located within the damage zone assumed, the stepped bulkhead is to be considered as covered by the damage when dealing with compartment flooding.

2.1.6 If any damage of a lesser extent than specified in 2.2 may result in a more severe condition as regards damage trim and stability of a damaged unit, such a damage is to be considered when making check calculations of the damage trim and stability.

2.1.7 Where pipelines, ducts and tunnels are located within the damage zone assumed, their design is to prevent progressive flooding of compartments considered as not flooded.

2.1.8 The arrangements for unit's equalization after damage are to be approved by the Register and be automatically activated if practicable.

Where controllable cross-flooding arrangements are available, slide valve control stations are to be located above the bulkhead deck.

2.2 EXTENT AND ZONES OF DESIGN DAMAGES

2.2.1 Damage trim and stability of damaged semi-submersible MODU in transit are to meet the requirements of 2.5 and 2.6 both in damage of sides and transoms and in damage of the bottom, and the requirements of 2.5 for other damaged units.

2.2.1.1 Design extent of outboard side and transom damages:

.1 longitudinal extent: $1/3L^{2/3}$ or 14,5 m (whichever is less);

.2 horizontal penetration: 1,5 m for self-elevating MODU, and 1,5 m or 0,2 of the lower hull breadth (whichever is greater) for submersible and semi-submersible MODU and FOP;

.3 vertical extent: from the base line upwards without limit.

At unusually large draughts and elevations of the bulkhead deck above the waterline in transit, the vertical extent may be assumed from the line located 10 m below the waterline (with due regard for trim) upwards up to the line located 7 m above the waterline (with due regard for trim as well).

2.2.1.2 Design extent of bottom damages:

.1 longitudinal extent: 1/3 $L^{2/3}$ or 5 m (whichever is less);

.2 transverse extent: $B/6$ or 5 m (whichever is less); B is equal to the sum of lower hull breadths for double-hulled units;

.3 vertical extent as measured in the center plane from hull body lines, 1 m.

2.2.2 For units in transit the following damages may be assumed:

.1 side or transom damage not affecting subdivision bulkheads spaced at a distance not less than specified in 2.2.1.1, at any place along the hull perimeter (of lower hulls — for submersible and semi-submersible MODU and FOP) with due regard for an actual possibility to be holed in the area under consideration;

.2 bottom damage between transverse and longitudinal bulkheads if they are spaced at a distance not less than specified in 2.2.1.2.1 and 2.2.1.2.2.

Where the distance between adjacent bulkheads is less than the design extent of the assumed damage specified in 2.2.1.1, 2.2.1.2.1 and 2.2.1.2.2, the joint flooding of adjacent compartments is to be considered. In this case, the distance between the bulkheads bounding the flooding area is to be not less than the design damage extent.

2.2.3 In calculations of damage trim and stability confirming compliance with the requirements of 2.5 and 2.6 for semi-submersible MODU according to 1.5.2.2 while being afloat in operational condition, the following damage extent for columns and bracings is assumed:

.1 longitudinal extent 1/8 of the stability column perimeter at the level of an actual waterline or 2,5 m (whichever is greater);

.2 horizontal penetration: 1,5 m;

.3 vertical extent: 3 m.

2.2.4 It is to be taken as destroyed watertight horizontal platforms and vertical bulkheads, trunks, piping, etc. which may be covered by damages specified in 2.2.3 in any place of the zone bounded by:

two outer quadrants (180°) at middle columns;

three outer quadrants (270°) at corner columns;

8 m along the height (5 m above and 3 m below the actual waterline with due regard for trim).

The above zones may be altered if it is proved to the Register that damage in this or that zone is impossible due to structural or sufficiently effective organizational arrangements performed which are provided for in the specific design.

2.2.5 Where any damage of lesser extent than that specified in 2.2.1 and 2.2.3 may result in more severe consequences, it is to be considered when calculating damage trim and stability.

2.2.6 All piping is assumed as damaged in the area of a design damage. Provision is to be made for measures to prevent progressive flooding through damaged pipelines.

2.3 PERMEABILITY

2.3.1 In damage trim and stability calculations the permeability of a flooded space is to be assumed equal to:

.1 0,85 — for spaces occupied by machinery, electric power plants, as well as by industrial machinery;

.2 0,95 — for accommodation spaces, voids including empty tanks;

.3 0,6 — for spaces intended for dry stores.

2.3.2 The permeability of flooded tanks containing a liquid cargo or liquid stores or water ballast is determined on the assumption that the contents are completely lost from those tanks and replaced by sea water with due regard for the permeability equal to 0,95.

2.3.3 The permeabilities of spaces may be assumed less than those specified above, provided a special calculation of permeability is made, which is approved by the Register.

2.3.4 Where the arrangement of spaces or operation conditions of the unit are such that the expediency of the application of other permeabilities resulting in more severe requirements is evident, the Register is entitled to demand the application of the latter, more severe permeabilities.

2.4 NUMBER OF FLOODED COMPARTMENTS

2.4.1 The requirements for trim and stability of a damaged unit are to be met at flooding of any compartment with the damages specified in 2.2.

The exception may concern the number of flooded compartments for stability columns of semi-submersible MODU with the design damage whose extent and location are specified in 2.2.3 and 2.2.4, as well as for hulls whose adjacent bulkhead spacing is less than the corresponding design damage extent specified in 2.2.1.1, 2.2.1.2.1 and 2.2.1.2.2.

2.4.2 The necessity to ensure damage trim and stability at flooding of any two or three adjacent compartments over the whole length and breadth of the hull or part thereof is established by the owner.

2.5 REQUIREMENTS FOR DAMAGED UNITS' TRIM AND STABILITY CHARACTERISTICS

2.5.1 The damage waterline prior to taking measures on equalization and after it is to run below the bulkhead deck outside the damage area. This requirement may be ignored when the damage waterline prior to the equalization process and after it runs at least 0,3 m below openings in bulkheads, decks and sides through which progressive flooding is possible.

By openings through which progressive flooding of a unit is possible are meant the outlets of air and vent pipes, as well as cutouts closed by weathertight doors and covers.

The following may be excluded from the above:

side and deck scuttles of the non-opening type;

manholes closed by covers with closely fitted bolts;

watertight sliding remotely-controlled doors provided they are located outside the design damage zone.

The hatches of small dimensions and hinged watertight doors may be subject to special consideration by the Register with due regard for their operation under specific conditions, as well as for structural and organizational arrangements for their closing.

2.5.2 The initial metacentric height corresponding to an inclination in relation to any possible axis in the final stage of flooding, as calculated by the constant displacement method, prior to taking measures on equalization and/or improving stability is to be at least 0,3 m.

2.5.3 The angle of inclination determined with due regard for heel and trim angles is not to exceed 7° in the final stage of flooding after taking measures on equalization. The angle of inclination prior to equalization is specified in 2.5.5.2.

2.5.4 The static stability curve of a damaged unit is to have the sufficient area of positive arm sections. In the final stage of flooding therewith, as well as after equalization the maximum statical arm is to be at least 0,3 m.

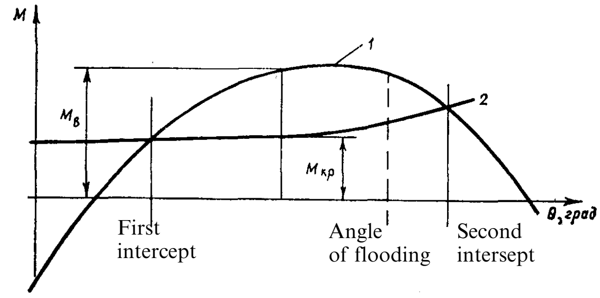
2.5.5 The damaged unit including a drilling ship (the last is in addition to 1.1.2) is to have sufficient stability in a damaged condition to withstand a statically applied heeling moment due to a wind from any direction having a velocity of 25,8 m/s (50 knots). In this case, with due regard for the static action of the wind:

.1 the waterline of a damaged unit is to run below the lower edge of any opening through which progressive flooding may happen regarding the provisions on openings specified in 2.5.1;

.2 the angle of inclination is not to exceed 17°;

.3 the extent of a static stability curve section with positive arms from the angle of inclination, with due regard for a wind action, to the angle of flooding or the second intersection of wind moment and righting moment curves (depending on the angle which is the least) is to be at lest 7°. As the angle of flooding the angle should be taken at which water enters the openings not having watertight or weathertight closures through which the water may penetrate intact compartments;

.4 within the range of a static stability curve, a righting moment curve is to reach the value of at least twice the wind heeling moment curve, both being measured at the same angle of inclination (see Fig. 2.5.5.4).



$M_R \geqslant 2M_W$

Fig. 2.5.5.4 Righting moment (1) and wind heeling moment (2) curves

2.6 ADDITIONAL REQUIREMENTS FOR TRIM AND STABILITY OF DAMAGED SEMI-SUBMERSIBLE UNITS

2.6.1 In addition to 2.5.5.1 to 2.5.5.4, it is required that any opening, whose lower edge is less than 4 m above the damage waterline (with due regard for a wind action stipulated in 2.5.5), is to be weathertight.

2.6.2 A semi-submersible unit is to withstand under any operational conditions and in transit the flooding of any watertight compartment (of one irrespective of its dimensions), wholly or partly situated below the waterline. Such a compartment may be either a space containing ballast pumps or a space containing machinery with a seawater cooling system, or a space adjacent to sea water. In this case:

.1 the angle of inclination in the final stage of flooding is not to exceed 25°;

.2 any opening located below the waterline in the final stage of flooding is to be watertight;

.3 the extent of a static stability curve having positive arms with due regard for the angle of flooding is to be at least 7°.

2.6.3 In transit or in an operational condition the requirement of 2.6.2 does not apply to spaces containing ballast pumps or machinery with a sea-water cooling system when these pumps or machinery are not to function in one of the two operational conditions and if these spaces are not adjacent to sea water.

2.7 CONDITIONS OF SUFFICIENT BUOYANCY AND STABILITY FOR FOP DAMAGED MODULES

2.7.1 Damage trim and buoyancy of a module with a flooded compartment or compartments are considered satisfactory if:

.1 the initial metacentric height of the module in the final stage of flooding for non-inclined condition as determined by the constant displacement method, prior to taking measures on its increase, is at least 0,05 m;

.2 the angle of inclination does not exceed 25°;

.3 the extent φ_+ of a static stability curve having positive arms with due regard for the angle of flooding is at least 20°. This value may be reduced down to φ_+ 10° provided the curve section area with positive arms is at least (20°/ φ_+) 0,0175 m. rad;

.4 the damage waterline prior to, in the course of and after equalization runs at lest 0,3 m below the openings in bulkheads, decks and sides through which progressive flooding is possible;

.5 the bulkhead deck and even the open deck may be immersed in water.

2.7.2 The value of the maximum arm of a static stability curve is to be at least 0,1 m within the range specified.

In the intermediate stages of flooding the above value is to be at least 0,05 m, and the extent of the positive part of the static stability curve is to be at least 7°.

PART VI. FIRE PROTECTION

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of this Part of MODU/FOP Rules applies to structural fire protection of MODU/FOP, fire extinguishing systems and fire detection and alarm systems, as well as to fire-fighting equipment and outfit. In addition to the requirements of this Part, the relevant requirements of Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships are to be met.

1.1.2 Fire protection requirements relating to the structural members of MODU/FOP hull, machinery and parts thereof, electrical equipment, pumping and piping, arrangements, fuel and lubricating oil tanks, construction and location of boilers, refrigerating plants, spaces, etc are set out in the relevant parts of MODU/FOP Rules.

1.1.3 Special equipment and outfit (fire extinguishing systems and fire detection and alarm systems, fire extinguishing installations, portable fire fighting outfit items, etc) intended for fire preventing and fighting in the drilling and industrial area and not covered by the present Part, are to meet their requirements to the extent agreed with the Register in each particular case.

The necessity of installing such equipment and outfit and characteristics thereof are to be determined by the Customer having regard to the presence and number of special salvage teams on board the MODU/FOP and the presence of ships assigned the mark **П** added to their class notation in the MODU/FOP water area.

The scope of the Register supervision of the said equipment and outfit is to be determined by the Customer and agreed with the Register.

1.1.4 Layout of the drilling and industrial equipment, as well as technical solutions to ensure safe drilling and well operation, collection, storage, treatment and transportation of the well products are to conform to the requirements of the competent State bodies exercising supervision of the safety in oil and gas industry.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 The definitions and explanations relating to the general terminology of the Rules are given in the General Regulations for the Classification and Other Activity and in Part I "Classification" of MODU/FOP Rules. Definitions and explanations concerning fire protection are stated in 1.2, Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships.

1.2.2 Unless otherwise provided, the following definitions have been adopted in this Part.

Accommodation spaces are cabins, messrooms, gymnasiums, toilets, hospitals, pantries containing no cooking appliances and similar spaces.

Service spaces are galleys, bakeries, pantries containing cooking appliances, storerooms, workshops other than those forming part of machinery spaces and similar spaces.

Industrial equipment spaces are spaces containing equipment intended for collection, storage, treatment and transportation of the well products.

Machinery spaces of Category A and other machinery spaces see 1.2, Part VII "Machinery Installations" of the Rules for the Classification and Construction of Sea-Going Ships.

Control stations are those spaces in which the radio or main navigating equipment or the emergency source of power is located or where the fire extinction and alarm control equipment is centalized.

Drilling area is a part of MODU/FOP which contains equipment intended for well drilling.

Industrial area is a part of FOP which contains equipment intended for well operation and associated processes of collection, storage, treatment and transportation of the FOP well products.

Hazardous zones and areas see 2.9, Part X "Electrical Equipment" of MODU/FOP Rules.

Attending personnel are persons who, for the purpose of this Part of the Rules, permanently or temporarily stay on board MODU/FOP in connection with the unit's mission or because of special work being performed on the unit.

Lower flammable limit is minimum concentration of oil gases and vapours in the air capable of igniting from a source of ignition and propagating combustion in the mixture.

H class divisions are those divisions, which are formed by bulkheads and decks complying with the following requirements:

they are to be constructed of steel or equivalent material;

they are to be suitably stiffened;

they are to be so constructed as to be capable of precluding the passage of smoke and flame during 120 min of the standard fire test;

they are to be so insulated with non-combustible material or equivalent fire-protective means that the average or maximum (at any point) temperature at the unexposed side will not rise more than 140 °C and 180 °C, respectively, above the original temperature.

Depending on the time, during which the above indicated temperature rise is ensured in the course of the standard fire test, the following symbols are given to divisions: H-120 – during 120 min, H-60 – during 60 min, H-0 – during 0 min.

Fire integrity of divisions is tested according to IMO Resolution A.754(18) "Recommendation on Fire Resistance Tests for "A', "B" and "F" class Divisions" considering that the time-dependent standard temperature curve corresponds to the international standard ISO 834-1 "Fire Resistance Tests-Elements of Building Construction. General Requirements".

1.3 FIRE PLANS

1.3.1 At the main machinery control room or in conspicuous positions in corridors and lobbies of MODU/FOP, there are to be exhibited general arrangement plans clearly showing the following for each deck:

.1 location of control stations;

.2 arrangement of fire-resisting and fire-retarding divisions;

.3 spaces fitted with the fire detection and alarm system;

.4 spaces protected by fixed fire extinguishing systems with indication of the location of instruments and fittings for their control and also the disposition of fire hydrants;

.5 arrangement of fire-fighting outfit;

.6 means of access to different spaces and to decks with indication of escape routes, corridors and doors;

.7 ventilation system including disposition of dampers and fan controls and the identification numbers of fans;

.8 location of documents referred to in 1.3.6.

1.3.2 A stitched set of plans with information specified in 1.3.1 is to be supplied to each officer, and one copy is to be available at all times on board in a readily accessible position.

1.3.3 A set of the plans protected against marine environment is to be permanently stowed outside the superstructure in a weathertight enclosure painted red and marked as indicated in Fig. 1.3.3-1.

The enclosure is to be capable of being easily opened, be readily available to the salvage teams , be

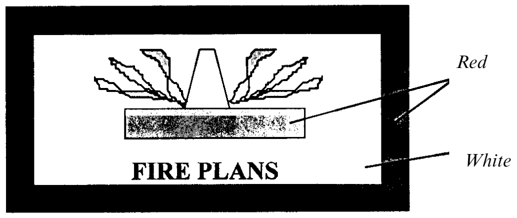


Fig 1.3.3-1

located in a well-illuminated position, if possible, including illumination from an emergency source.

The enclosure is not to be located in a hazardous zone and on exterior bulkheads of superstructures which face hazardous zone and on side bulkheads abutting thereon.

If the enclosure is not adjacent to place of boarding of the salvage teams, there are to be guide signs as indicated in Fig. 1.3.3-2 showing the way thereto.

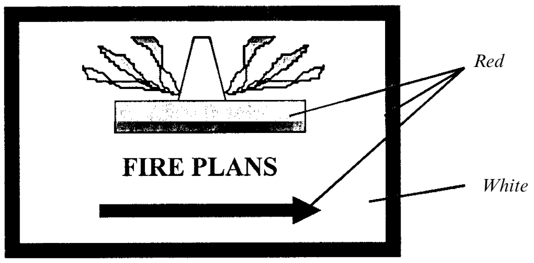


Fig. 1.3.3-2

The dimensions of the signs are to be not less than 300 × 400 mm.

The signs are to be arranged at the same level and the spacing between them is not to exceed 50 m.

1.3.4 Plans and booklets are to be made in the state language and are to contain translation into English. The symbols for items listed in 1.3.1 are to be in agreement with IMO Resolution A.654(16) "Graphical Symbols for Fire Control Plans".

For FOP engaged in operations on the Russian continental shelf, translation into English is not required.

Graphical symbols are to be coloured.

1.3.5 Plans and booklets are to be continuously updated and any alterations in the fire protection are to be entered therein at the earliest possible date.

1.3.6 To be kept in a separate file in an accessible position are technical instructions for maintenance and use of all installations for extinction and containment of fire.

2 STRUCTURAL FIRE PROTECTION

2.1 GENERAL

2.1.1 Requirements for structural fire protection of FOP.

2.1.1.1 To provide effective structural fire protection all relevant requirements of 2.1, Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships are to be applied.

2.1.1.2 The hull, superstructures, structural bulkheads and decks are to be constructed of steel.

The Register may allow the use of other materials depending on the purpose, size and arrangement of spaces on the FOP.

2.1.1.3 Superstructure on FOP, if its length exceeds 50 m and the number of attending personnel exceeds 100 persons, in way of accommodation and service spaces is to be divided into main vertical zones by "A-60" class divisions. Steps and recesses are to be kept to a minimum, but where they are necessary they are also to be "A-60" class divisions. Where a space of categories (*8*), (*9*) indicated in 2.1.1.7.2 is on one side of the division the class may be reduced to "A-0".

Bulkheads forming the boundaries of main vertical zones are to extend from deck to deck and to the exterior boundaries of superstructure or other boundaries.

Where the main vertical zone is divided by horizontal "A" class divisions into horizontal zones for the purpose of providing an appropriate barrier between sprinklered and non-sprinklered zones of the FOP, the divisions are to extend between adjacent main vertical zone bulkheads and to exterior boundaries of the FOP and are to be insulated in accordance with the fire insulation and fire integrity values given in Table 2.1.1.7-2.

2.1.1.4 All bulkheads in accommodation and service spaces which are not required to be "A" class divisions are to be at least "B" class and "C" class divisions as prescribed in Table 2.1.1.7-1.

2.1.1.5 All corridor bulkheads which are not required to be "A" class divisions are to be "B" class divisions which are to extend from deck to deck except:

.1 when continuous "B" class ceilings or linings are fitted on both sides of the bulkhead, the portion of the bulkhead behind the continuous ceiling or lining is to be of material which, in thickness and composition, is acceptable in the construction of "B" class divisions but which is to be required to meet "B" class fire integrity standards only in so far as is reasonable and practicable;

.2 in case of a FOP protected by an automatic sprinkler system the corridor bulkheads of "B" class materials may terminate at ceiling in the corridor provided such a ceiling is of material which, in thickness and composition, is acceptable in the construction of "B" class divisions. Such bulkheads and ceilings are to be required to meet "B" class fire integrity standards only in so far as is reasonable and practicable. All doors and frames in such bulkheads are to be of non-combustible materials and are to be fitted in such a way as to provide sufficient fire resistance.

2.1.1.6 All bulkheads required to be "B" class divisions, except corridor bulkheads required by 2.1.1.5, are to extend from deck to deck and to the exterior boundaries of superstructure or other boundaries unless the continuous "B" class ceilings or linings, having at least the same fire integrity as the bulkhead, are fitted on both sides of it, in which case the bulkhead may terminate at the continuous ceiling or lining.

2.1.1.7 On FOP, the minimum fire integrity of bulkheads and decks separating adjacent spaces is to be as prescribed in Tables 2.1.1.7-1 and 2.1.1.7-2. The following requirements are to govern application of the tables:

.1 tables are to apply respectively to the bulkheads and decks separating adjacent spaces;

.2 for determining the appropriate fire integrity standards to be applied to divisions between adjacent spaces, such spaces are classified according to their fire risk as shown in 15 categories below. The title of each category is intended to be typical rather than restrictive.

(*1*) Control stations:

spaces in which the emergency sources of power and lighting are located;

spaces containing radio equipment;

fire extinction stations, fire control stations and fire alarm stations;

main machinery control room provided it is located outside the machinery space containing main machinery;

spaces containing centralized fire announcing system;

spaces in which emergency loudspeaking communication equipment and central station is situated.

(*2*) Stairways and lifts:

interior stairways, lifts and escalators and enclosures thereto;

a stairway or lift which is enclosed only at one level is to be regarded as part of the space from which it is not separated by a fire door.

Table 2.1.1.7-1

Bulkheads not bounding either main vertical zones or main horizontal zones

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Control stations	(1)	A-0[1]	A-0	A-0	A-0	*	A-60	A-15	A-0	A-0	A-15	A-60	A-60	A-60	N.A.	A-60
Stairways and lifts	(2)		A-0[1]	A-0	A-0	*	A-0	A-15	A-0[4]	A-0	A-15	A-60	A-30	A-15	N.A.	A-60
Corridors	(3)			C[2]	A-60	*	B-0[2]	B-0[2]	B-0[2]	A-0	A-0	A-60	A-15	A-15	N.A.	A-60
Evacuation stations and external escape routes	(4)					*	A-60[3]	A-60	A-0	A-0	A-60[3]	A-60[3]	A-60[3]	A-60[3]	A-60	A-60
Open decks	(5)					—	*	*	*	*	*	*	*	*	*	*
Accommodation spaces	(6)						C[2]	B-0[2]	C[2]	A-0	A-0	A-60	A-15	N.A.	N.A.	N.A.
Service spaces (low fire risk)	(7)							C[2]	A-0	A-0	A-0	A-0	A-0	A-0	A-60	A-60
Sanitary and similar spaces	(8)								C[2]	A-0	A-0	A-0	A-0	A-0	N.A.	A-0
Tanks and voids	(9)									A-0[1]	A-0	A-60	A-0	A-0	A-0	A-0
Machinery spaces of Category A	(10)										A-0[1]	A-60	A-0	A-60	A-60	A-60
Other machinery spaces	(11)											A-0[1]	A-60	A-60	A-60	A-60
Service spaces (high fire risk)	(12)												A-0[1]	A-30	A-60	A-60
Oil storage	(13)													A-0[1]	A-60	A-0
Industrial area	(14)														A-0[1]	A-0
Drilling area	(15)															—

[1] Where the space are used for the same purpose, no divisions may be fitted between them.

[2] Where the divisions are the main vertical zone divisions required by 2.1.1.3 they are to be of "A-60" class standard.

[3] Fire integrity of FOP side below the waterline, superstructure sides situated below and adjacent to the liferafts and evacuation slides may be reduced to "A-30".

[4] Where toilets are installed completely within stairway enclosure, fire integrity of the toilet bulkhead within the stairway enclosure may be of "B" class.

Notes: 1. Where, due to any particular structural arrangements in the FOP, difficulty is experienced in determining from the table the minimum fire integrity value of any divisions, such values are subject to special consideration by the Register.

2. Where the contents and use of a space are such that there is a doubt as to its classification, it is to be treated as space within the relevant category having the most stringent boundary requirements.

3. Where a dash appears in the table, it means that there are no special requirements for material or fire integrity of boundaries.

4. Letters N.A. mean that the adjacent space arrangement is not applicable.

5. Where an asterisk "*" appears in the table, the division is to be of steel or equivalent material, but need not be of "A" class. However, where the division is penetrated for the passage of electric cables, pipes, etc, such penetrations are to be fitted with sealings of approved type.

Table 2.1.1.7-2

Decks not forming steps in main vertical zones nor bounding horizontal zones

Spaces		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Control stations	(1)	A-0	A-0	A-0	A-0	*	A-15	A-0	A-0	A-0	A-0	A-60	A-60	N.A.	N.A.	N.A.
Stairways and lifts	(2)	A-0	*	A-0	A-0	*	A-0	A-0	A-0	A-0	A-0	A-60	A-30	A-0	N.A.	A-0
Corridors	(3)	A-15	A-0	*	A-60	*	*	*	A-0	A-0	A-15	A-60	A-30	N.A.	N.A.	N.A.
Evacuation stations and external escape routes	(4)	A-0	A-0	A-0	A-0	—	A-0	A-0	A-0	A-0	A-0	A-0	A-0	N.A.	N.A.	N.A.
Open decks	(5)	*	*	*	*	—	*	*	*	*	*	*	*	—	—	—
Accommodation spaces	(6)	A-60	A-15	A-0	A-60	*	*	*	A-0	A-0	A-0	A-60	A-0	N.A.	N.A.	N.A.
Service spaces (low fire risk)	(7)	A-60	A-30	A-15	A-60	*	A-15	*	A-0	A-0	A-0	A-60	A-0	A-0	A-0	A-0
Sanitary and similar spaces	(8)	A-0	A-0	*	A-0	*	*	*	*	A-0	A-0	A-0	A-0	N.A.	N.A.	N.A.
Tanks and voids	(9)	A-0	A-0	A-0	A-0	*	A-0	A-0	A-0	*	A-0	A-0	A-0	A-0	A-0	A-0
Machinery spaces of Category A	(10)	A-60	A-60	A-60	A-60	*	A-60	A-60	A-0	A-0	A-30	*	A-60	A-30	A-60	A-30
Other machinery spaces	(11)	A-60	A-60	A-60	A-60	*	A-0	A-0	A-0	A-0	*	A-0	A-30	A-30	A-60	A-30
Service spaces (high fire risk)	(12)	A-60	A-30	A-15	A-60	*	A-15	A-30	A-0	A-0	A-0	A-60	A-0[1]	N.A.	A-0	A-0
Oil storage	(13)	A-60	A-60	A-60	A-60	A-0	A-0	A-0	A-0	A-0	A-0	A-0	A-30	*	A-0	N.A.
Industrial area	(14)	N.A.	A-60	A-60	N.A.	A-0	N.A.	N.A.	A-0	A-0	N.A.	N.A.	A-60	N.A.	A-0	A-0
Drilling area	(15)	A-60	A-60	A-60	A-60	—	A-0	A-0	A-0	A-0	A-0	A-60	A-0	N.A.	A-0	—

[1] See footnote to Table 2.1.1.7-1.

Notes: see notes to Table 2.1.1.7-1.

(*3*) Corridors:

corridors and lobbies.

(*4*) Evacuation stations and external escape routes:

survival craft stowage area;

open deck spaces and enclosed decks forming lifeboat and liferaft embarkation and lowering stations;

internal and external muster stations;

external stairs and open decks used for escape routes;

the FOP side to the waterline , superstructure sides situated below and adjacent to the liferaft's and evacuation slide's embarkation areas.

(*5*) Open decks:

open deck spaces (spaces outside the superstructures), excluding drilling and industrial areas, which are not adjacent to these areas.

(*6*) Accommodation spaces:

spaces as defined in 1.2.2, excluding corridors.

(*7*) Service spaces (low fire risk):

lockers and store-rooms in which flammable liquids cannot be stored;

drying rooms;

workshops other than those forming part of machinery space.

(*8*) Sanitary and similar spaces:

communal sanitary spaces, laundries, shower rooms, water closets, etc.

(*9*) Tanks and voids:

water tanks forming part of the unit's structure;

voids and cofferdams;

sea-water pipe tunnels;

closed passages and trunks serving the spaces listed above.

(*10*) Machinery spaces of Category A:

spaces as defined in 1.2.2.

(*11*) Other machinery spaces:

spaces as defined in 1.2.2 other than machinery spaces of Category A;

tanks for fuel oil and other oil products (if installed in a separate space containing no machinery);

fuel oil and industrial pipe tunnels;

closed passages and trunks serving the spaces listed above.

(*12*) Service spaces (high fire risk):

galleys, pantries containing cooking appliances;

storerooms containing flammable liquids (including paints, medicines, etc);

laboratories in which flammable liquids are stored.

(*13*) Oil storage:

tanks and other reservoirs intended for storage of oil, including slop tanks.

(*14*) Industrial area:

area as defined in 1.2.2.

(*15*) Drilling area:

area as defined in 1.2.2.

2.1.2 Requirements for structural fire protection of MODU.

2.1.2.1 To provide effective structural fire protection all relevant requirements of 2.1, Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships are to be applied.

2.1.2.2 To provide effective structural protection of the accommodation and service spaces on MODU, method 1C referred to in 2.3, Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships is to be used.

2.1.2.3 On MODU, the minimum fire integrity of bulkheads and decks separating adjacent spaces is to be as prescribed in Tables 2.1.2.3-1 and 2.1.2.3-2. The following requirements are to govern application of the tables:

.1 tables are to apply respectively to the bulkheads and decks separating adjacent spaces;

.2 for determining the appropriate fire integrity standards to be applied to divisions between adjacent

Table 2.1.2.3-1

Fire integrity of bulkheads separating adjacent spaces

Spaces		(*1*)	(*2*)	(*3*)	(*4*)	(*5*)	(*6*)	(*7*)	(*8*)	(*9*)	(*10*)
Control stations	(*1*)	A-0[1]	A-0	A-60	A-0	A-15	A-60	A-15	A-60	A-60	*
Corridors	(*2*)		C	B-0	A-0 B-0[2]	B-0	A-60	A-0	A-60	A-0	*
Accommodation spaces	(*3*)				A-0 B-0[2]	B-0	A-60	A-0	A-60	A-0	*
Stairways and lifts	(*4*)				A-0 B-0[2]	A-0 B-0[2]	A-60	A-0	A-60	A-0	*
Service spaces (low fire risk)	(*5*)					C	A-60	A-0	A-60	A-00	*
Machinery spaces of Category A	(*6*)						*	A-0	A-60	A-60	*
Other machinery spaces	(*7*)							A-0[3]	A-0	A-0	*
Drilling area	(*8*)								*	A-60	*
Service spaces (high fire risk)	(*9*)									A-0[3]	*
Open decks	(*10*)										—

[1] Bulkheads separating spaces containing radio and navigational equipment from each other may be of "B-0" class.

[2] For clarification of the type of division, see 2.1.4.3., Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships.

[3] Where spaces are used for the same purpose, divisions between them may not be fitted.

Note. Where an asterisk "*" appears in the table, the division is required to be of steel or other equivalent material but is not required to be of "A" class material. However, where a division is penetrated for the passage of electric cables, pipes, etc, such penetrations are to be fitted with sealings of approved type.

Table 2.1.2.3-2

Fire integrity of decks separating adjacent spaces

Spaces		(*1*)	(*2*)	(*3*)	(*4*)	(*5*)	(*6*)	(*7*)	(*8*)	(*9*)	(*10*)
Control stations	(*1*)	A-0	A-0	A-0	A-0	A-0	A-60	A-0	—	A-0	*
Corridors	(*2*)	A-0	*	*	A-0	*	A-60	A-0	—	A-0	*
Accommodation spaces	(*3*)	A-60	A-0	*	A-0	*	A-60	A-0	—	A-0	*
Stairways and lifts	(*4*)	A-0	A-0	A-0	*	A-0	A-60	A-0	—	A-0	*
Service spaces (low fire risk)	(*5*)	A-15	A-0	A-0	A-0	*	A-60	A-0	—	A-0	*
Machinery spaces of Category A	(*6*)	A-60	A-60	A-60	A-60	A-60	*	A-60[4]	A-0	A-60	*
Other machinery spaces	(*7*)	A-15	A-0	A-0	A-0	A-0	A-0	*	A-0	A-0	*
Drilling area	(*8*)	—	—	—	—	—	A-60	A-0	*	—	*
Service spaces (high fire risk)	(*9*)	A-60	A-0	A-0	A-0	A-0	A-60	A-0	—	A-0[3]	*
Open decks	(*10*)	*	*	*	*	*	*	*	*	*	*

[1,2,3] See respective footnotes to Table 2.1.2.3-1.

[4] Where other machinery spaces are the spaces of low fire risk, i.e. they do not contain machinery operating on fuel oil or having a pressure lubrication system, "A-0" class divisions are permitted.

N o t e . Where an asterisk "*" appears in the table, the division is required to be of steel or other equivalent material but is not required to be of "A" class material. However, where a division is penetrated for the passage of electric cables, pipes, etc, such penetrations are to be fitted with sealing of approved type.

spaces, such spaces are classified according to their fire risk, as shown in 10 categories below. The title of each category is intended to be typical rather than restrictive.

(*1*) Control stations:

spaces as defined in 1.2.2.

(*2*) Corridors:

corridors and lobbies.

(*3*) Accommodation spaces:

spaces as defined in 1.2.2, excluding corridors.

(*4*) Stairways and lifts:

interior stairways, lifts and escalators and enclosures thereto;

a stairway or a lift which is enclosed only at one level is to be regarded as part of space from which it is not separated by a fire door.

(*5*) Service spaces (low fire risk):

lockers and store-rooms in which flammable liquids are not stored, drying rooms and laundries.

(*6*) Machinery spaces of Category A:

spaces as defined in 1.2.2.

(*7*) Other machinery spaces:

spaces as defined in 1.2.2 other than machinery spaces of Category A.

(*8*) Drilling area:

area as defined in 1.2.2.

(*9*) Service spaces (high fire risk):

galleys, pantries containing cooking appliances;

lockers and store-rooms in which flammable liquids are stored (including paints, medicines, etc);

workshops other than those forming part of machinery space.

(*10*) Open decks:

open deck spaces and enclosed decks containing no fire risk. Open deck spaces (spaces outside the superstructures and deckhouses), excluding drilling area, which are not adjacent to drilling area.

2.1.3 Stairways, escape routes.

2.1.3.1 Stairways situated within superstructures are to be protected by divisions with self-closing doors.

2.1.3.2 A stairway connecting only two decks need not be enclosed, provided the fire integrity of the deck is maintained in one tweendeck space. Where a stairway is enclosed in one tweendeck space, the stairway enclosure is to be protected in accordance with the requirements of Tables 2.1.1.7-2 and 2.1.2.3-2.

2.1.3.3 Stairway enclosures are to have direct communication with the corridors and be provided with landings as required by 8.5.4.2, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships. Within the perimeter of such stairway enclosures, only public toilets, lockers for storage of salvage and fire fighting outfit are permitted. Only public spaces, corridors, public toilets, external areas and other stairways required by 8.5, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships are permitted to have direct access to these stairway enclosures.

2.1.3.4 Furniture is not to be permitted in corridors forming escape routes in accommodation areas.

2.1.3.5 Parts of escape routes to the survival craft embarkation stations, which are arranged in such a way that in the event of fire at the drill floor they are not protected by structures or equipment against direct effects of that fire, are to be protected by water curtain on the drill floor side.

2.1.4 Fire-resisting and fire-retarding divisions.

2.1.4.1 Exterior boundaries of superstructures and deckhouses enclosing accommodation spaces, control stations, assembly stations and escape routes, as well as machinery and service spaces connected therewith are to be constructed to:

.1 H-60 standard for the whole of the portion, which faces the drilling or industrial area liable to heat effect in case of fire in the specified areas;

.2 A-60 standard for all the rest areas.

2.1.4.2 Issues of loss of carrying capacity by the basic structures during fire are subject to special consideration by the authorized bodies supervising safety of oil and gas industry.

2.1.5 Closures of openings in fire-resisting and fire-retarding divisions.

2.1.5.1 Where the exterior boundaries of superstructures and deckhouses facing the drilling or industrial area, as well as the adjoining outward sides for a distance of 3 m are required to be fitted with windows and side scuttles, the latter are to be of non-opening type to meet the requirements of 7.2, Part III "Equipment, Arrangements and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships. Wheelhouse windows on MODUs may be of opening type which would permit their rapid closure.

Windows and side scuttles in "A-60" class divisions which face the drilling or industrial area are to be constructed to "A-60" class and fitted with shutters of steel or equivalent material.

2.1.5.2 No doors to accommodation spaces, control stations and service, machinery spaces connected therewith and other spaces directly communicating with such spaces are to be fitted in the exterior boundaries of superstructures and deckhouses facing the drilling or industrial area and also on adjoining outward sides for a distance of 3 m.

2.1.5.3 No doors, windows and other openings are to be generally arranged within a sphere with a radius of 3 m and a centre situated at the point of drilling mud diversion.

2.1.5.4 External doors, other than watertight doors, in superstructures and deckhouses enclosing accommodation spaces, control stations and service, machinery spaces connected therewith are to be constructed to "A-0" class and be self-closing.

2.2 LOCATION OF SPACES

2.2.1 Spaces containing equipment intended for well drilling, collection, storage, treatment and transportation of well products are not to be adjacent to accommodation spaces and control stations and are to be enclosed by "A-0" class divisions.

2.2.2 Accommodation spaces, control stations and service and machinery spaces connected therewith, in so far as is reasonable and practicable, are to be located collectively in the superstructure separated from the drilling and industrial area.

2.2.3 Siting of superstructures and deckhouses is to be such that in the event of fire at the drill floor at least one escape route to survival craft is protected against radiation effects of that fire.

2.2.4 No fuel oil and lubricating oil tanks are to be located adjacent to the accommodation and service spaces, as well as to the escape routes in the superstructure.

2.3 HELICOPTER FACILITIES

2.3.1 Helicopter facilities (helideck, hangar, refuelling station, fuel tanks) are to be removed from the drilling and industrial area, and from the areas containing sources of ignition, as well as from the spaces where large amounts of heat are produced. They are not to be adjacent to accommodation spaces.

The facilities are to be so located that in the event of fire in the drilling or industrial area they are protected by the superstructures against direct effects of that fire.

2.3.2 Helideck, its supporting structures and hangar are to be constructed of steel.

2.3.3 Where spaces are provided below the helideck, such spaces are to be isolated from the deck by "A-60" class divisions.

2.3.4 Helideck and areas for refuelling are to be clearly marked and provided with coamings to prevent fuel from spreading beyond the limits of these areas. Arrangements for collecting and draining fuel spillage are to be independent of any other arrangements.

2.3.5 Refuelling station for helicopters is to meet the following requirements:

.1 the boundaries and means of closing openings at the station are to secure gas tightness thereof. Doors leading to the station are to be of steel;

.2 deck coverings are to preclude spark formation. Arrangements and machinery are to be so arranged and located as to exclude the possibility of spark formation;

.3 pipelines and cables passing through the boundaries of the station are not to cause loss of its gas tightness;

.4 storage tank fuel pumps are to be provided with means which permit remote shutdown from a safe location in the event of fire;

.5 where several fuel tanks are fitted, the fuel system design is to provide for fuel supply to the helicopter being refuelled only from one tank at a time;

.6 provision is to be made for the arrangement whereby a fuel spillage may be collected and drained into an off-grade fuel tank;

.7 the fuel oil piping is to be of steel or equivalent material, as short as possible, and protected against damage;

.8 the refuelling facility is to incorporate a metering device to record the quantity of supplied fuel, a flexible hose with a nozzle fitted with a self-closing valve and a device to prevent over-pressurization of the fuel system.

2.3.6 The fuel tanks are to be made of materials which resist attacks by corrosion and helicopter fuel.

Fuel may be stored both in fixed and transported tanks.

Tanks are to be efficiently secured, closed and bonded. The tanks are to be readily accessible for inspection.

Fixed tanks may be installed on open decks. In so doing, the tanks are to be protected against physical damages and from direct influence of sunbeams.

Where such tanks are equipped with arrangements for their emergency jettisoning, measures are to be taken to prevent a jettisoned tank from striking the MODU/FOP structures. The tanks are to be situated away from the survival craft embarkation and lowering areas.

The fuel tanks are also to comply with the requirements of Part VIII "Systems and Piping" of MODU/FOP Rules.

2.3.7 The number and arrangement of fire hydrants is to be such as to provide three jets of water for any part of the hangar and two jets for any part of the helideck.

2.3.8 The helideck is to be protected by foam smothering system consisting of monitors or foam generators capable of delivering foam to any part of the helideck in all weather conditions in which helicopters can operate. The system is to be capable of delivering a discharge rate as required in Table 2.3.8 for at least five minutes.

Table 2.3.8

Category of helideck	Helicopter overall length, m	Discharge rate of foam solution (l/min.)
H1	up to but not including 15 m	250
H2	from 15 m up to but not including 24 m	500
H3	from 24 m up to but not including 35 m	800

2.3.9 In close proximity to the helideck, the following fire-fighting appliances are to be provided and stored near the means of access to that deck:

at least one fire-extinguisher containing not less than 45 kg of dry powder or not less than 90 kg of carbon dioxide;

at least two fire-extinguishers each containing 5 kg of carbon dioxide or equivalent fire-extinguishers containing gaseous extinguishing medium, one of these extinguishers being so equipped as to enable it to reach the engine area of any helicopter;

at least two dual purpose nozzles and hoses capable of delivering 250 l/min of water to any part of the helideck;

two complete sets of fireman's outfit including protective clothing, helmet with a visor, mittens, isolating breathing apparatus with spare charges;

fire smothering blanket.

2.3.10 "NO SMOKING" signs are to be displayed at appropriate locations.

2.3.11 General aviation requirements for the helicopter facilities on board ships, which may be applicable to the MODU/FOP, are to be taken into account.

2.4 SPACES FOR WELDING OPERATIONS. FIXED OXYGEN AND ACETYLENE SYSTEM

2.4.1 Spaces for electric welding operations and areas for the storage of oxygen and acetylene cylinders are to comply with the requirements of 2.1.8, Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships.

2.4.2 Areas for the storage of oxygen and acetylene cylinders are not to be located in the vicinity of the drilling and industrial area.

2.4.3 Fixed piping system for oxygen and acetylene is to comply with the following requirements:

.1 pipes are to be made of steel or equivalent material and approved joints are to be fitted;

.2 material containing more than 70 per cent of copper is not to be used in the fittings, except for welding and cutting tips;

.3 allowance is to be made for expansion of piping;

.4 pipes are to be as short as possible and protected from physical damage.

3 FIRE-FIGHTING EQUIPMENT AND SYSTEMS

3.1 GENERAL

3.1.1 The requirements of this Section are applicable to all fire-fighting equipment and systems fitted on MODU/FOP.

Where provision is made on a FOP for extra fire-fighting equipment and/or systems in addition to those prescribed by this Section, such equipment and/or systems are to comply also with the requirements set out below, to the extent approved by the Register in each case.

The fire-fighting systems are also to comply with the requirements of Sections 2, 4, 5, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

3.1.2 In addition to the water fire main system and in accordance with the purpose for which they are intended, spaces of MODU/FOP are to be protected by one of the fixed fire extinguishing systems according to Table 3.1.2, unless expressly provided otherwise.

The use of other equivalent systems is subject to special consideration by the Register.

3.1.3 In well-grounded cases, instead of water-screen and drenching systems, fire-resisting and fire-retarding divisions may be used.

3.1.4 Decks in way of oil storage tanks and the tanks themselves are to be protected by a fixed deck foam fire extinguishing system and fixed inert gas system, except that instead of the above systems, the Register, considering the arrangement and equipment of the MODU/FOP, may accept other combinations of the systems, provided they ensure equivalent protection.

To be reckoned as equivalent, the system proposed instead of the deck foam fire extinguishing system is to:

extinguish oil spillage fire and prevent ignition of oil spillages which are not on fire yet;

extinguish fire in all opened oil storage tanks.

To be reckoned as equivalent, the system proposed instead of the fixed inert gas system is to:

prevent dangerous accumulation of explosive mixtures in the intact storage tanks during normal service and during necessary operations performed in the tanks;

Table 3.1.2

No	Description of spaces	Fixed fire extinguishing systems								
		Sprinkler	Pressure water-spraying	Water screen	Drenching	Foam	Carbon dioxide smothering	Inert gas	Dry powder	Aerosol
1	Accommodation spaces (excluding toilets, lavatories, shower-rooms, operating rooms, etc)	+[1]								
2	Service spaces (storerooms for combustible materials)	+[1]								+
3	Storerooms for flammable liquids, flammable liquified and compressed gases[5]		+			+[2]	+		+	+
4	Spaces for industrial equipment		+			+[3]	+			+
5	Open decks in way of hazardous zones		+			+[4]				
6	Machinery spaces of Category A and spaces containing separators. Hangars for helicopters and fuel distribution stations		+			+[3]	+			+
7	Silencers of internal combustion engines, exhaust has boilers, smoke uptakes of incinerators, exhaust ventilation ducts of galleys and bakeries		+				+			
8	Means of escape (see 2.1.3.5)			+						
9	Exits from machinery spaces and industrial equipment spaces enclosed in trunks				+[6]					
10	Helideck					+				
11	Oil collecting tanks					+[4]		+[7]		

[1] With attending personnel not over 100 in number — on agreement with the Customer; with attending personnel over 100 in number — the system is compulsory

[2] A system using medium expansion foam with expansion ratio of about 100:1 is to be used.

[3] A system using foam with expansion ratio of about 1000:1 is to be used.

[4] A system using foam with expansion ratio of 10:1, 100:1 (or combination foam) with the use of monitors is to be provided.

[5] Storerooms for flammable liquids, liquified and compressed gases, paint lockers need not be fitted with a fixed fire extinguishing system, if the volume of each storage space is not more than 4 m^2.

[6] Required if the trunk is constructed of "A-0" class divisions. To be fitted outside the trunk.

[7] The need is to be decided by the Customer.

be so designed as to minimize the ignition hazard due to static electricity which can be formed by the system itself.

3.1.5 Arrangement of fire-fighting equipment and installation of fire extinguishing system pipes in the areas of zones to be specified is to be carried out , as far as practicable, in such a way as to avoid damage risk in the event of emergency and to retain their operability.

3.1.6 In well-grounded cases, systems with automatic release of fire extinguishing medium are permitted, provided that a manual release is to be necessarily arranged and the possibility of a spontaneous release is eliminated, considering vibrations, shakings, impacts which can be associated with operation of the equipment on MODU/FOP.

3.1.7 FOP, fitted with tanker terminals, are to have in the tanker mooring area at least two monitors capable of delivering foam and water both to the oil loading area at the terminal and to the cargo deck of the tankers.

3.1.8 Instead of the drenching systems required to protect the areas: drilling; industrial equipment; oil and gas collectors; mud circulation and treatment; piping containing oil and gases; compressed gas cylinders (oxygen and acetylene), etc located on open deck, water and foam monitors may be used, provided that they are capable of delivering extinguishing medium to any part of the areas. A combined method using monitors and drenching may be permitted.

3.1.9 The MODU/FOP is to be provided with an international shore connection. Facilities are to be available enabling such a connection to be used on any side of the unit.

3.2 WATER FIRE MAIN SYSTEM

3.2.1 At least two independently driven fixed fire pumps are to be provided. Each of the fire pumps is to have a minimum capacity of 60 m^3/h. On units with high suction lift water may be taken from sea water storage tanks filled by submersible or other pumps.

3.2.2 One of the fire pumps is to be intended for fire-fighting.

3.2.3 The arrangements of sea suctions, pumps and sources of power are to be such as to ensure that a fire in any one space is not to put both the required pumps out of action.

3.2.4 The total capacity and head of the required pumps are to be appropriate to ensure operation of two fire hose nozzles and simultaneous operation of other fire-fighting systems using water and required for fighting a fire in one of the spaces or areas on open deck of the MODU/FOP, for which the maximum quantity of water is required.

3.2.5 Each pump is to be capable of delivering at least two jets of water simultaneously from any two fire hydrants through 19 mm nozzles while maintaining a minimum pressure of 0,35 MPa at any hydrant. In addition, where a foam system is provided for the protection of the helideck, the pumps are to be capable of maintaining a minimum pressure of 0,7 MPa at the foam installation.

If the water consumption for any other fire protection or fire-fighting purpose exceeds the rate of the helideck foam installation, this consumption is to be the determining factor in calculating the required capacity of the fire pumps.

3.2.6 Where the fire pumps are located in spaces not normally manned, suitable provision is to be made for remote start-up of those pumps and remote operation of associated suction and discharge valves to be effected either from the main machinery control room or from one of the positions where watchkeepers are present when the unit is in operating condition.

3.2.7 Sea water storage tanks are to comply with the requirements of 3.3.2.2, Part VIII "Systems and Piping" of MODU/FOP Rules.

The capacity of the tanks is to be such that minimum permissible amount of water therein permits the operation of two fire hose nozzles during 15 min, but in any case the capacity is to be not less than 10 m^3.

3.2.8 The fire main is where practicable to be routed clear of hazardous areas and be arranged in such a manner as to make maximum use of physical protection afforded by the structure of the unit.

3.2.9 The fire main is to be provided with isolating valves located so as to permit optimum utilization of the main in the event of physical damage to any part thereof.

3.2.10 The fire main is not to have connections other than those necessary for fire-fighting purposes.

3.2.11 Sanitary, bilge, ballast and other sea water pumps may be accepted as fire pumps, provided their capacity and head correspond to those required and they are not normally used for pumping oil.

3.2.12 On units with attending personnel over 100 in number, the water fire main system is to be kept under pressure at all times, and the fire main is to be arranged in way of superstructures as a ring one with shut-off valves fitted to keep the system operable when certain sections of the ring main are disconnected.

3.2.13 Every centrifugal pump which is connected to the fire main is to be provided with a non-return valve fitted on the delivery pipe.

3.3 DRENCHING SYSTEM

3.3.1 The drenching system is intended for protection of areas and spaces as specified in Table 3.1.2.

3.3.2 The system is to be operated from positions outside the areas and spaces to be protected.

3.3.3 The design capacity of the pumps supplying the system is to be sufficient to provide a rate of water discharge which is to be not less than 12 l/min per 1 m^2 of the deck area concerned.

3.3.4 Each area is to be protected by a section (sections) forming part of a common drenching system and connected thereto through shut-off valves used to disconnect the section (sections) in the event of failure.

3.4 WATER-SCREEN SYSTEM

3.4.1 The water-screen system is provided to ensure protection of areas and spaces as specified in Table 3.1.2.

3.4.2 The system is to be operated from positions outside the areas and spaces to be protected.

3.4.3 The water-screen system is to be generally fed from the water fire main. The design capacity of the pumps supplying the system is to be sufficient to provide at least 70 l/min per linear metre of the screen length.

4 FIRE DETECTION AND ALARM SYSTEMS

4.1 FIRE DETECTION SYSTEM

4.1.1 Each unit is to be provided with an automatic fire detection system.

4.1.2 In addition to the spaces referred to in 4.2.1, Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships, automatic fire detectors are to be fitted in the spaces within hazardous zones and areas 1 and 2 specified in 2.9, Part X "Electrical Equipment" of MODU/FOP Rules.

4.2 MANUAL FIRE ALARMS

4.2.1 Each unit is to be provided with manual fire alarms.

4.2.2 In addition to the spaces referred to in 4.2.1, Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships, manual fire alarms are to be fitted in the spaces within hazardous zones and areas 1 and 2 specified in 2.9, Part X "Electrical Equipment" of MODU/FOP Rules

4.3 GAS DETECTION AND ALARM SYSTEM AND EQUIPMENT

4.3.1 Fixed automatic gas detection and alarm systems are to be provided for monitoring a concentration of:

oil gases and vapours;

hydrogen sulphide.

The need for fixed gas detection and alarm systems to be provided on FOP for monitoring a concentration of hydrogen sulphide is to be identified based on the results of hydrogen sulphide detection in the formation fluid of the first exploratory well. The need for such system on a FOP is to be decided by the Customer and approved by the Register.

4.3.2 A gas detection and alarm system is to function continuously and is to ensure:

.1 giving visual and audible signals at the appropriate local control station, drill master's cabin, industrial production station and at the main machinery control room when the concentration of oil gases and vapours is in the range (20 ± 10) per cent from the lower flammable limit and that of hydrogen sulphide is 3 mg/m^3.

.2 starting the ventilation system for operation with maximum air changes per hour in the space;

.3 cutting off the sampling devices or oil gas or vapour detectors operating on thermochemical principle when hydrogen sulphide concentration reaches 10 mg/m^3 with a signal being given to the main machinery control room;

.4 giving alarm signal at the main machinery control room to indicate failure in the system itself.

4.3.3 Visual signals to indicate oil gas and vapour concentration are to be distinct from the signals to indicate hydrogen sulphide concentration.

4.3.4 The components of the system are to meet the requirements of Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships.

4.3.5 The design of detectors and instruments fitted in hazardous zones and areas is to meet the requirements of 2.11, Part X "Electrical Equipment" of MODU/FOP Rules.

4.3.6 Sampling devices are to be made of materials resistant to the attack of oil gases and hydrogen sulphide vapours. The diameter and length of the piping is to be based on the supply time of gas sample to the detector to be not in excess of 60 s.

4.3.7 Use of change-over devices which provide successive gas monitoring in several points is permitted. The fixed position is to be maintained during the time period sufficient for a gas sample to pass to the detector.

4.3.8 Positions of the oil gas or vapour concentration sampling devices or detectors (hydrogen sulphide concentration detectors) are dictated by the field facilities construction project with due regard for the density of gases, technical data and location of the equipment used.

4.3.9 On drilling units, gas sampling devices or detectors of the oil gas/vapour monitoring system are to be fitted:

.1 in spaces:

in way of delivery side of each drilling mud and cement pump at a height of not more than 0,5 m above the deck or above the continuous plating;

above the drilling mud tanks at a height of 0,2 m above their upper edge and at a height of 0,5 m above the deck where they are fitted;

near the shale shaker at a distance of not more than 1,0 m, horizontally, at a height of not more than 0,5 m above it;

.2 on open decks — near the drilling mud diverter, at least in four points at a distance of not more than 1 m therefrom. Where the diverter is located in semi-enclosed spaces, not less than in two points.

4.3.10 On drilling units, gas sampling devices or detectors of hydrogen sulphide monitoring system are to be fitted:

.1 in spaces containing drilling mud tanks, drilling mud pumps and mud circulating system:

in the working area at a height of not more than 1 m above the deck or above the continuous plating;

near the shale shaker at a distance of not more than 1 m therefrom at a height of 1 m above the deck (floor);

.2 in open and semi-enclosed areas — near the drilling mud diverter.

4.3.11 A unit is to be provided with:

.1 two portable gas monitoring devices capable of measuring a concentration of oil gases and vapours;

.2 two portable gas monitoring devices capable of measuring a concentration of hydrogen sulphide.

5 FIREMAN'S OUTFIT, SPARE PARTS AND TOOLS

5.1 GENERAL

5.1.1 As a minimum, the fireman's outfit, spare parts and tools are to comply with Section 5, Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships as applied to oil tankers and as far as the helicopter facilities are concerned they are to comply with 2.3.9.

Use of a smoke helmet and a smoke mask with an air hose and air pump is not permitted in the fireman's outfit.

5.1.2 For FOP having superstructure divided into main vertical fire zones, provision is to be made for two additional fireman's outfits for each zone.

PART VII. MACHINERY INSTALLATIONS AND MACHINERY

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part apply to machinery installations, engines, machinery equipment of machinery spaces essential to the safety of MODU/FOP.

Apart from the requirements of the present Part, the machinery installations of MODU/FOP are subject to all the applicable requirements specified in Parts VII, VIII, IX, X, XII and XV of the Rules for the Classification and Construction of Sea-Going Ships. These requirements cover also the equipment, systems and piping of industrial and drilling complexes, as appropriate.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations relating to the general terminology are given in the General Regulations for Classification and Other Activity, Part I "Classification" and Part VI "Fire Protection" of the Rules for the Classification and Construction of Sea-Going Ships. Besides, all applicable definitions and explanations of Part VII "Machinery Installations" of the Rules for the Classification and Construction of Sea-Going Ships are also used.

For the purpose of the present Part, the following definitions have been adopted

Main control room of MODU/FOP is a space containing the remote controls of main machinery and propellers of self-propelled MODU, machinery and arrangements of jacking systems of self-elevating MODU, submersion and raising systems of submersible and semi-submersible MODU, machinery, equipment and arrangements providing generation of electrical power, as well as safe operation of MODU/FOP, and fitted with instrumentation, alarms and means of communication.

General purpose machinery spaces are spaces containing machinery, equipment and arrangements intended for generating electrical power and to assure safe operation of MODU/FOP.

Industrial machinery spaces are spaces containing machinery, equipment and arrangements intended for constructing and operating the well.

Control stations are those spaces where the main navigational equipment, radio equipment, emergency sources of power, fire detection and fire control equipment, dynamic positioning control systems as well as ballast control systems for semi-submersible and submersible MODU are located. However, for the purpose of application of the requirements of Part VI "Fire Protection" of MODU/FOP Rules, the space where the emergency source of power is located is not considered as a control station.

Industrial machinery and equipment are machinery and equipment intended for performing drilling operations.

Industrial spaces are open or enclosed spaces where the industrial equipment and machinery not covered by 1.2.5 and 2.9, Part X "Electrical Equipment" of MODU/FOP Rules are situated.

1.3 SCOPE OF SUPERVISION

1.3.1 General provisions relating to classification procedure, supervision during construction and surveys, as well as requirements for technical documentation to be submitted to the Register for consideration and approval are set forth in the General Regulations for Classification and Other Activity and in Part I "Classification" of the Rules for the Classification and Construction of Sea-Going Ships and in Part I "Classification" of MODU/FOP Rules.

1.3.2 In the process of MODU/FOP construction the machinery, equipment and systems covered by Parts VII, VIII, IX, X, XII and XV of the Rules for the Classification and Construction of Sea-Going Ships are subject to supervision by the Register during manufacture, installation and tests.

Apart from that, the following is to be supervised by the Register:

.1 jacking systems and arrangements of self-elevating MODU;

.2 remote control system of the jacking arrangements of self-elevating MODU;

.3 hydraulic driving machinery, lifting (lowering) arrangements of sea water supply pipes and submersible sea water pumps of self-elevating MODU;

.4 hydraulic drive for closing preventers.

2 MACHINERY INSTALLATIONS

2.1 GENERAL

2.1.1 Power output of the main machinery in the drilling ships is to be chosen in accordance with 2.1, Part VII "Machinery Installations" of the Rules for the Classification and Construction of Sea-Going Ships, while the output of main machinery of the self-propelled MODU is to be sufficient to maintain steerability of the MODU when going backward under all normal operating conditions.

2.1.2 All the external rotating parts of machinery and equipment (couplings, shafts, drives, belts, etc on the pumps, compressors, coolers, gas turbines and engines) are to be protected by guards.

2.1.3 Where the equipment with increased noise level is used measures are to be taken to abate noise.

2.1.4 Surfaces of the machinery, equipment and pipes which can be heated up to a temperature in excess of 220 °C are to be insulated.

2.2 ENVIRONMENTAL CONDITIONS

2.2.1 All machinery, equipment and systems essential to the safe operation of MODU are to remain operative under the following conditions:

2.2.1.1 Static conditions:

.1 when a semi-submersible or submersible MODU is inclined to an angle up to 15° inclusive in any direction;

.2 when a self-elevating MODU is inclined to an angle up to 10° inclusive in any direction;

.3 when a drilling ship is inclined to an angle of 15° and simultaneously trimmed to an angle of 5°.

2.2.1.2 Dynamic conditions for self-propelled MODU and drilling ships:

.1 when a semi-submersible or submersible MODU is inclined to an angle up to 22,5° inclusive in any direction;

.2 when a self-elevating MODU is inclined to an angle of 15° inclusive in any direction;

.3 drilling ships at 22,5° rolling and simultaneous 7,5° pitching.

2.2.2 The emergency sources of power are to remain operative under the following conditions:

.1 when a semi-submersible or submersible MODU is inclined to an angle up to 25° inclusive in any direction;

.2 when a self-elevating MODU is inclined to an angle up to 15° inclusive in any direction;

.3 drilling ships at 22,5° rolling and simultaneous 10° pitching.

2.2.3 In 2.2.1 and 2.2.2 the heeling angles are given for inclination either way, and the trimming and pitching angles are given for inclination by bow or stern. On agreement with the Register, the values of inclinations given in 2.2.1 and 2.2.2 may be altered depending on the type, dimensions and service conditions of the MODU.

2.3 ARRANGEMENT OF MACHINERY AND EQUIPMENT

2.3.1 Internal combustion engines are generally not permitted to be installed in hazardous spaces (see 2.9, Part X "Electrical Equipment" of MODU/FOP Rules) and areas. Where this cannot be avoided, special consideration by the Register will be required.

2.3.2 Air intakes for internal combustion engines and boilers are to be at a distance not less than 3 m from hazardous areas.

2.3.3 Oil- or gas-fired boilers are not to be installed in hazardous spaces and areas.

2.3.4 Pressure vessels of riser tensioning systems and heave compensating devices located on open decks and platforms are to be protected from mechanical damage and radiation effects.

2.3.5 Drilling equipment in which oil products may be present is not to be located in spaces housing the main and auxiliary machinery.

2.4 CONTROL STATIONS

2.4.1 In general, the main control room of MODU/FOP is to be located outside the machinery spaces and as far from hazardous areas as practicable.

2.4.2 The equipment of the main machinery control room of MODU is to comprise:

.1 controls of main machinery and propellers;

.2 controls of the jacking arrangements of self-elevating MODU;

.3 controls of the submersion and raising systems of semi-submersible and submersible MODU;

.4 instruments to monitor the operation of jacking arrangements of self-elevating MODU, submersion and raising arrangements of semi-submersible and submersible MODU;

.5 indicating devices to show that the jacking arrangements and remote control systems are in operational readiness;

.6 devices to monitor the MODU hull position (heel, trim, draught, clearance, etc.);

.7 devices for disconnection of any of the jacking arrangements in case of its failure;

.8 devices for actuation of the emergency arresters relieving the hydraulic system (if any);

.9 means of communication;

.10 alarms to warn of the troubles in jacking arrangements of self-elevating MODU, and in submersion/raising arrangements of semi-submersible and submersible MODU.

2.4.3 In addition to the devices listed in 3.2.1, Part VII "Machinery Installations" of the Rules for the Classification and Construction of Sea-Going Ships the main machinery control room of the MODU is to be equipped with alarm and indication facilities according to 3.1.2.5.5, Part VIII "Systems and Piping" of MODU/FOP Rules.

2.4.4 Every jacking arrangements of self-elevating MODU is to be operable locally. The local control station is to comprise:

.1 controls of the jacking arrangements;

.2 instruments to monitor operation of the jacking arrangements (pressure in hydraulic drive circuits, hydraulic control systems, hydraulic cylinder spaces);

.3 means of two-way communication with the main machinery control room of MODU/FOP;

.4 automatic overrides of local control when a dangerous inclination is reached.

2.5 MEANS OF COMMUNICATION

2.5.1 Two-way communication is to be provided between the main control room of MODU/FOP and machinery control room located in the machinery space.

2.5.2 Two-way communication is to be provided between the ballast control station and the spaces in which the ballast pumps, valves and other equipment used in ballasting operations are situated.

2.5.3 Two-way communication is to be provided between the drilling foreman's position and the machinery control room located in the machinery space, the main control room and other spaces containing equipment essential to the safety of MODU/FOP.

2.6 MACHINERY SPACES

2.6.1 Machinery spaces (see 1.2.2, 1.2.3 of the present Part and 1.2, Part VII "Machinery Installations" of the Rules for the Classification and Construction of Sea-Going Ships), as well as non-hazardous industrial machinery spaces are generally not to communicate with hazardous spaces and areas (see 2.9, Part X "Electrical Equipment" of MODU/FOP Rules). If such communication cannot be avoided the relevant requirements of 2.9, Part X "Electrical Equipment" of the MODU/FOP Rules are to be met so that the safety of the machinery spaces and non-hazardous industrial machinery spaces is not affected.

2.6.2 Every attended space or space which requires often visits of personnel is to have at least two escape routes arranged in the opposite ends of the space. Dead-end corridors exceeding 5 m in length are not to be permitted in such spaces.

2.6.3 Hazardous industrial machinery spaces (see 1.2.6) are to have at least two means of escape, one of which is to lead directly to the open deck.

2.7 VIBRATION OF MACHINERY AND EQUIPMENT

2.7.1 Vibration of machinery and equipment listed in 1.1 is not to exceed levels given in Section 9, Part VII "Machinery Installations" of the Rules for the Classification and Construction of Sea-Going Ships and is not to hinder operation of industrial machinery and equipment (see 1.2.2).

2.7.2 Vibration induced by industrial machinery and equipment is not to disturb normal operation of machinery and equipment listed in 1.1.

2.7.3 All the machinery and equipment are to be installed on the foundations by a method that precludes onset of vibrations with unacceptable amplitudes when operating at full load with due regard for the possible seismic effect of the MODU/FOP site.

2.8 REFRIGERATING PLANTS

2.8.1 The MODU/FOP are covered by all the requirements of Part XII "Refrigerating Plants" of the Rules for the Classification and Construction of Sea-Going Ships regarding unclassed and classed refrigerating plants in so much as applicable.

2.8.2 Spaces containing refrigerating machinery and refrigerant piping are to be located outside the hazardous spaces and areas.

3 MACHINERY

3.1 GENERAL

3.1.1 Machinery components listed in Table 3.1.1 of the present Part, as well as in Table 1.2.4, Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships are to be supervised by the Register during manufacture with respect to observance of the requirements given in Part XIII "Materials" and Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships and MODU/FOP Rules, as well as the approved technical documentation specified in 1.2.3, Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships.

Table 3.1.1

No	Components	Material	Extent of testing
1	Jacking systems of self-elevating units		
1.1	Hydraulic cylinder, cover, rod	Forged steel	3.7.6[1]
1.2	Hydraulic cylinder piston	Ditto	Ditto
1.3	Securing parts	Ditto	Ditto
1.4	Traverses of hydraulic cylinders	Ditto	Ditto
1.5	Power transmission components (shafts, gear wheels and pinions of jacking arrangements)	See item 3 of Table 1.2.4[2]	
2	Lifting/lowering arrangements of outboard piping and submersible sea water pumps	See item 7 of Table 1.2.5[2]	
3	Submersible sea water pumps	See item 5 of Table 1.2.5[2]	

[1]Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.
[2]Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships.

3.1.2 It is permitted to utilize the power of main engines to drive the drilling machinery. In such case, the main engines are to be fitted with efficient means of protection from possible overload.

3.1.3 Electrical equipment of the engines and machinery is to comply with the relevant requirements of Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships.

3.1.4 All the machinery and equipment essential to the safety of MODU are to remain operative under the conditions specified in 2.2.1 to 2.2.3.

3.2 INTERNAL COMBUSTION ENGINES

3.2.1 Engines intended for use in MODU/FOP are to comply with the requirements of Sections 2 and 9, Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships in so much as they are applicable.

3.3 GAS TURBINES

3.3.1 Gas turbines intended for use in MODU/FOP are to comply with the requirements of Section 8, Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships in so much as they are applicable.

3.4 AUXILIARY MACHINERY

3.4.1 Auxiliary machinery intended for use in MODU/FOP is to comply with the requirements of Section 5, Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships in so much as they are applicable.

3.5 DECK MACHINERY

3.5.1 Deck machinery intended for use in MODU/FOP is to comply with the requirements of Section 6, Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships in so much as they are applicable.

3.6 JACKING ARRANGEMENTS

3.6.1 General requirements for the jacking arrangements of self-elevating MODU:

.1 design of jacking arrangements is to ensure the reliable operation of the jacking system in all positions of the MODU hull possible under service conditions;

.2 jacking arrangements are to be so designed as to enable them to be immediately put in operation for the intended service;

.3 failure or malfunction of any element of the hydraulic system or control circuit is not to cause damage of the jacking system.

3.6.2 General requirements for arrangements to lift (lower) the outboard piping and submersible sea water pumps:

.1 the driving means are to provide lowering of the outboard piping and submersible sea water pumps down to a limit level during a period of time of not more than 10 min;

.2 provision is to be made for audible and visual alarm and protection to operate as soon as the limit levels of lifting/lowering are reached.

3.6.3 Loaded components of jacking arrangements listed in 3.6.1 and 3.6.2 are to be checked for strength by calculation under application of maximum forces likely to occur in service conditions of the MODU. The ultimate strength of the components is to be determined in such case having regard to the safety factors in accordance with 2.4.2, Part II "Hull" of MODU/FOP Rules.

3.7 HYDRAULIC DRIVES

3.7.1 Hydraulic drives intended for use in MODU/FOP are to comply with the requirements of Section 7, Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships in so much as they are applicable.

3.8 GEARS, DISENGAGING AND ELASTIC COUPLINGS

3.8.1 Gears, disengaging and elastic couplings intended for use in MODU/FOP are to comply with the requirements of Section 4, Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships in so much as they are applicable.

PART VIII. SYSTEMS AND PIPING

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part of the Rules cover the following piping systems.

1.1.1.1 General purpose piping systems:
bilge system;
ballast system;
air, overflow and sounding pipes;
ventilation and air conditioning system of accommodation and service spaces.

1.1.1.2 Machinery piping systems:
fuel oil system;
lubricating oil system;
cooling water system;
compressed air system;
exhaust gas system;
feed water system;
condensate system;
steam and blow-off piping systems;
thermal oil systems;
ventilation system of machinery spaces, accumulator battery rooms and boxes.

1.1.1.3 Special systems:
ventilation system of hazardous spaces;
sea water supply system of self-elevating MODU;
hydraulic jacking system of MODU;
fuel system for helicopters;
process systems;
emergency mud dumping system.

As applied to the process systems the requirements of the present Part are to be taken into account to the extent which is indispensable for ensuring watertight integrity, explosion and fire safety of the unit.

1.2 DEFINITIONS

1.2.1 For the purposes of the present Part the following definitions have been adopted:

Piping system is a combination of pipelines, machinery, apparatus, devices, appliances and reservoirs intended for performance of certain functions providing units' operation.

Pipeline is a combination of pipes, fittings, any internal and external linings, coatings, insulation, fastening elements and components for protection of pipes, intended for conveying of liquid, gaseous and compound media, as well as for transmission of pressure and sound waves.

Valves are stop, safety and regulating devices, intended for motion control, distribution and regulation of consumption and other parameters of the conveying medium by means of full or partial opening or closing of flow section.

1.3 SCOPE OF SUPERVISION

1.3.1 General provisions relating to the procedure of supervision during construction and surveys, as well as requirements for the scope of technical documentation to be submitted for consideration and approval to the Register are to comply with the General Regulations for the Classification and Other Activity.

1.3.2 The technical documentation to be submitted to the Register for consideration and approval is to include also schematic diagrams of the process systems conveying dangerous and flammable media.

1.4 PROTECTION AND INSULATION OF PIPING

1.4.1 Pipes are to be protected against corrosion and against excessive pressure, as well as insulated with due regard for the requirements of 1.4, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

1.5 WELDING AND NON-DESTRUCTIVE EXAMINATION OF WELDS

1.5.1 Welding and non-destructive testing of welds is to be effected in compliance with 1.5, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

1.6 MACHINERY, APPARATUS AND CONTROL DEVICES

1.6.1 Pumps, compressors, fans and their driving machinery; heat exchangers and pressure vessels, as well as control and monitoring devices and facilities used in systems mentioned in 1.1 are to comply with the requirements of 1.6, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

2 GENERAL REQUIREMENTS FOR PIPING SYSTEMS

2.1 METAL PIPING

2.1.1 The requirements for materials used for manufacturing of pipes and fittings, permissible radii of pipe bends and heat treatment after bending, permissible pipe wall thicknesses and pipe joints are outlined in Section 2, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

2.2 PLASTIC PIPING

2.2.1 Plastic pipes used in the units are to be manufactured, assembled and tested in compliance with the requirements of Section 3, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

2.3 HOSES

2.3.1 Hoses used on the MODU/FOP are to comply with the requirements of Section 6, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

2.4 VALVES

2.4.1 Construction of the manually and remotely operated valves, their marking, arrangement and installation, construction of the sea-inlet water boxes and ice boxes, bottom and side valves, openings in shell plating is to comply with the requirements of Section 4, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

2.4.2 Where a system is equipped with remote-controlled power actuated valves, means are to be also provided to operate the valves manually.

2.4.3 Inlet and discharge valves in spaces located below the waterline are to be provided with remote-controlled valves operable from a position outside these spaces.

Where remote operation is provided by power actuated valves for sea-water inlets and discharges for operation of propulsion and power generating machinery, a failure in the power supply of the control system is not to result in closing of open valves or opening of closed valves.

Use of bilge alarms instead of remote control of the valves may be only permitted for self-elevating MODU, semi-submersible MODU and FOP.

2.5 PIPING LAYING

2.5.1 Piping laying through watertight and fire-resisting structures, in tanks, in the vicinity of electrical and radio equipment, in unattended machinery spaces, as well as in other spaces is to be effected with due regard for the requirements of Section 5, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

2.5.2 Pipes conveying non-hazardous media are to be separated from pipes which may contain dangerous and flammable media.

Cross-connection may be permitted by the Register in the event that measures are taken to prevent possible fouling of pipes containing non-hazardous medium.

2.5.3 Where pipelines or vent ducts of MODU serve more than one compartment or are located in the region of assumed flooding (see 3.4, Part V "Subdivision" of MODU/FOP Rules), structural precautions are to be taken to prevent progressive flooding of other compartments through these piping systems in case of damage.

For this purpose the pipelines and vent ducts are to be fitted with watertight shut-off devices to be installed on watertight bulkheads and decks and capable of being remotely operated from the upper deck.

2.6 TESTING OF PIPING SYSTEMS

2.6.1 The requirements for tests of the piping and fittings are outlined in Section 21, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

3 REQUIREMENTS FOR PIPING SYSTEMS DEPENDING ON THEIR PURPOSE

3.1 GENERAL PURPOSE PIPING SYSTEMS

3.1.1 Bilge system.

3.1.1.1 Unless expressly specified otherwise, the applicable requirements of Section 7, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships are to be complied with.

3.1.1.2 Watertight compartments and all the compartments below bulkhead deck, containing equipment essential for operation and safety of the unit, are to have a permanently installed bilge or drainage system.

The system is to be capable of draining the compartments effectively under all practical conditions, whether the unit is upright or inclined, as specified in 3.5, Part V "Subdivision" of MODU/FOP Rules.

3.1.1.3 Dry compartments which are adjacent to the sea or adjacent to the tanks containing liquids and void compartments through which pipes conveying liquids pass are to have permanently installed bilge system or portable means of dewatering.

3.1.1.4 All distribution boxes and manually operated valves in connection with the bilge pumping arrangements are to be in positions which are readily accessible under ordinary circumstances.

Where such valves are located in normally unmanned spaces below the assigned load line and not provided with high bilge water level alarms, they are to be remotely operable from outside the spaces in addition to the local control.

3.1.1.5 Means are to be provided to signal the presence of water in compartments which are adjacent to the sea or adjacent to the tanks containing liquids, as well as in void compartments through which pipes conveying liquids pass.

3.1.1.6 The permanently installed bilge system mentioned in 3.1.1.2 is to be served by at least two independently driven power pumps or similar equipment.

Independent ballast and sanitary pumps of adequate capacity may be accepted as bilge pumps.

3.1.1.7 The cross-sectional area of the bilge main is to be not less than the total cross-sectional area of the two largest branch suctions.

The internal diameter d, in mm, of branch suctions from each compartment being emptied is to be not less than that determined by the formula, to the nearest standard dimension:

$$d = 2{,}15\sqrt{A} + 25 \qquad (3.1.1.7)$$

where A = the wetted surface, in m^2, of the compartment, excluding stiffening members, when the compartment is half filled with water. In any case, the internal diameter of any branch suction is not to be less than 50 mm.

3.1.1.8 The capacity of each bilge pump is to be sufficiently large to give the water a speed of at least 2 m/s through the bilge main.

Where more than two pumps are connected to the bilge main, their total capacity is to be not less than specified above.

3.1.1.9 The capacity of the bilge system for FOP is to be sufficient to drain the largest compartments to be served in case when the water-based fire-extinguishing means installed therein are used simultaneously.

3.1.1.10 On semi-submersible and submersible MODU, at least one of the bilge pumps is to be of submersible type with power source located on the working platform of the MODU.

3.1.1.11 On self-elevating MODU and drilling ships, the bilge pumps are to be arranged in separate watertight compartments or are to be of submersible type with power source located on the working platform of the MODU.

3.1.1.12 On each MODU, all valve chests and control fittings are to be arranged so that in the event of flooding of one bilge pump the other pump is capable of draining any flooded compartment.

3.1.1.13 On semi-submersible and submersible MODU, the bilge system is to be capable of being operated from permanently manned locations.

3.1.1.14 The machinery spaces of MODU with machinery, necessary for propulsion or positioning, as well as the normally unmanned pump rooms in lower hulls of stabilizing columns are to be provided with two independent systems for high bilge water level indication.

3.1.1.15 On semi-submersible and submersible MODU, the chain lockers which, if flooded, could substantially affect the stability of the unit are to be provided with remote means to detect flooding and with permanently installed means of dewatering.

Remote indication of flooding is to be provided at the ballast control station.

Means are to be also provided to remove dirt and sludge from the bilge or drainage system.

3.1.1.16 Hazardous and non-hazardous spaces are to have separate bilge or drainage systems.

3.1.1.17 The bilge system is not permitted to be combined with the waste water system of accommodation quarters.

3.1.2 Ballast system.

3.1.2.1 Unless otherwise specified, the applicable requirements of Section 8, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships are to be complied with.

3.1.2.2 The ballast system is to be served by at least two independently driven ballast pumps.

The pumps provided need not be dedicated ballast pumps, but are to be readily available for such use at all times.

A controlled gravity ballasting may be permitted.

3.1.2.3 The arrangement of suctions is to be such that any ballast tank can be deballasted in all positions of the MODU possible during operation.

3.1.2.4 Safeguards against accidental opening of suction valves in the operating or transit conditions of the MODU are to be provided.

3.1.2.5 Requirements for column stabilized units

3.1.2.5.1 The system is to be capable of pumping out any ballast tank by at least two power-driven pumps so arranged that tanks can be drained in any operating or transit conditions.

The ballast pumps are to be of self-priming type or be provided with a separate priming system.

3.1.2.5.2 The system is to be capable of raising the unit, starting from a level trim condition at deepest normal operating draft, to the severe storm draft, or a greater distance as may be specified by the Register, within three hours.

One of the ballast pumps and the ballast control system are to be arranged with electrical power supply from the main and emergency sources of power.

3.1.2.5.3 The ballast system is to be arranged so as to prevent inadvertent transfer of ballast water from one tank to another.

Transfer of the ballast water from one tank to another through a single valve is not permitted except when such a transfer does not adversely affect stability.

3.1.2.5.4 The ballast system is to be arranged so that even with any one pump inoperable, it is capable of restoring the unit to a level trim condition and draft acceptable with respect to stability, when subject to the damage conditions specified in 3.1, Part V "Subdivision" of MODU/FOP Rules.

3.1.2.5.5 Ballast pumps, ballast tank valves and sea chest valves are to be remotely operated and monitored from the central ballast control station.

Pumps are also to be fitted with means of local control in the pump room, and the valves are to be fitted with independent manual controls.

The central and back-up ballast control stations are to be located in enclosed spaces readily accessible in storm or damage condition. These spaces are not to be located within the assumed damage penetration zone.

The central ballast control station is to be provided with the following:

valve position-indicating system;

tank level indicating system;

draught indicating system;

means of communication with other stations from which ballast pumps and valves can be operated.

The control and indicating systems are to function independently of one another in such a way that a failure in one system does not affect the operation of the other systems. The control system of the ballast pumps and valves is to be so arranged that the failure of any component will not cause the loss of control of other pumps and valves.

Ballast tanks valves are to close automatically upon loss of power in order to prevent uncontrolled transfer of ballast water.

3.1.3 Thank vents, overflows and sounding pipes.

3.1.3.1 Tank vents, overflows and sounding pipes are to be arranged with due regard for the applicable requirements of Section 10, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships, unless otherwise specified.

3.1.3.2 Tank vents and overflows are to be located having regard to the damage stability and location of damage waterline.

Tank vents and overflows which could couse progressive flooding are to be avoided.

3.1.3.3 If the tank vent end openings become immersed in case the MODU in damaged condition is inclined to an angle not exceeding 5° with respect to damage waterline, such vents are to be fitted with automatic means of closing complying with the requirements of 10.1.8, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

3.1.3.4 The open ends of the vents of fuel and lubricating oil tanks are to be led to non-hazardous areas.

3.1.3.5 The height of the vents on self-elevating MODU from the deck to the liquid level in the vent is to be not less than 380 mm.

3.1.3.6 If the overflows from several integral tanks situated in different watertight compartments are combined into a common header, such header is to be arranged above the deepest immersion line of the MODU.

3.1.3.7 The height of the vents is to be chosen having regard to the permissible design pressure for the tank.

3.1.3.8 All the tanks are to be provided with individual sounding pipes or remote sounding arrangements whose design is approved by the Register.

Where a sounding pipe exceeds 20 m in length, the minimum internal diameter is to be equal to

38 mm. For pipes of greater length, the minimum internal diameter is to be increased to at least 50 mm.

3.1.3.9 For the tanks which are not always accessible, the remote level indicating system is to be supplemented with sounding pipes.

3.1.3.10 Void compartments adjacent to the sea or tanks containing liquids and void compartments through which pipes conveying liquids pass are to be fitted with separate sounding pipes, approved tank liquid level indicating apparatus or means to detect if the void tanks contain liquids.

3.1.4 Ventilation and air conditioning system of accommodation and service spaces.

3.1.4.1 The ventilation and air conditioning system of accommodation and service spaces on the MODU/FOP is to be arranged with due regard for the requirements of 12.1.1 to 12.1.3, 12.16, 12.17 and the applicable requirements of 12.2, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships, unless otherwise specified.

3.1.4.2 Ventilation system of non-hazardous spaces is to be separate from that of hazardous spaces. Attention is to be given to the relative positions of the inlets and outlets of the ventilation system to minimize the risk of mutual fouling.

Air inlets of ventilation ducts are to be arranged outside the hazardous areas and located as high and as remote therefrom as practicable.

3.2 MACHINERY SYSTEMS

3.2.1 Fuel oil system.

3.2.1.1 Unless otherwise specified, the applicable requirements of Section 13, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships are to be met.

3.2.1.2 The fuel pipelines are to be laid through non-hazardous spaces.

In general, the fuel pipes are not to be laid on working flats and in such locations where they can be subject to damage. In exceptional cases, arrangement of fuel pipes in the above-mentioned areas is permitted provided that reliable protection from mechanical damage is ensured.

3.2.1.3 The fuel tanks are to be separated from hazardous spaces by cofferdams. They are not to be arranged in hazardous areas.

3.2.1.4 The capacity of the fuel tank for emergency diesel generator is to meet the requirements of 9.3.1, Part X "Electrical Equipment" of the present Rules.

3.2.1.5 Bunkering is to be carried out through filling pipes led to above the open decks or platforms outside the hazardous areas.

Special bunkering stations are recommended to be provided for this purpose.

3.2.1.6 Where steam or air is used for atomization of the well bore fluids, a non-return valve is to be fitted on the air or gas pipeline.

Such valve is to be part of the permanently installed pipeline, be readily accessible and located as close to the oil burners as possible.

3.2.2 Lubricating oil system.

3.2.2.1 For drilling vessels, the requirements of Section 14, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships are to be met.

3.2.2.2 Prime movers of generators and emergency fire pumps are to be provided with self-contained lubricating oil systems.

3.2.3 Cooling water system.

3.2.3.1 Unless otherwise specified, the applicable requirements of Section 15, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships are to be met.

3.2.3.2 Cooling systems on self-elevating units are to ensure trouble- free operation of generator and auxiliary machinery prime movers under all service conditions, including lifting and descending of the unit.

3.2.3.3 Sea inlets are to be provided with strainers and filters. Means are to be provided to enable the filters to be cleaned without interrupting the cooling water supply.

3.2.4 Compressed air system.

3.2.4.1 Unless otherwise specified, the applicable requirements of Section 16, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships are to be met.

3.2.4.2 To start the diesel generators and to maintain functioning of the diesel engine control system, provision is to be made for a self-contained compressed air system.

3.2.4.3 The total amount of compressed air is to be sufficient to provide not less than six starts of the most powerful diesel engine among all the engines installed.

3.2.4.4 On the MODU, the compressed air in an amount indicated in 3.2.4.3 is to be stored in not less than two air receivers or two groups of air receivers.

3.2.4.5 Starting air pipes are to be completely separated from air pipes for industrial needs. Use of starting air for industrial needs is not permitted.

3.2.4.6 On the MODU, there are to be at least two starting compressors for replenishing the starting air receivers, one of which may be an attached compressor.

In case of failure of any one compressor, the capacity of the remaining ones is to be sufficient for filling of air receivers mentioned in 3.2.4.4 during an hour beginning from the pressure at which starting of the engine is possible up to the pressure required to provide six starts.

3.2.4.7 For all types of MODU, the requirement of 16.2.3, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships is to be complied with.

3.2.5 Exhaust gas system.

3.2.5.1 The exhaust gas pipes are to be laid and connected to equipment with due regard for the requirements of Section 11, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

3.2.5.2 The exhaust gas pipes of the internal combustion engines, the uptakes of boilers, galleys and incinerators are to be fitted with spark arresters of the design approved by the Register and are to terminate outside the hazardous areas.

3.2.6 Feed water system.

The boiler feed water systems of the MODU/FOP are to be arranged with due regard for the applicable requirements of Section 17, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

3.2.7 Condensate system.

The condensate systems of the MODU/FOP are to be arranged with due regard for the applicable requirements of Section 19, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

3.2.8 Steam and blow-off systems.

The steam and blow-off systems of the MODU/FOP are to be arranged with due regard for the applicable requirements of Section 18, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

3.2.9 Thermal oil systems.

The thermal oil systems of the MODU/FOP are to be arranged with due regard for the applicable requirements of Section 20, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

3.2.10 Ventilation system of machinery spaces, accumulator battery rooms and boxes.

The ventilation system of machinery spaces, accumulator battery rooms and boxes is to comply with the requirements of 12.1.1 to 12.1.7, 12.5 and 12.10, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

3.3 SPECIAL SYSTEMS

3.3.1 Ventilation system of hazardous spaces.

3.3.1.1 All enclosed hazardous spaces of Zone 1 and Zone 2 (see 2.9, Part X "Electrical Equipment" of MODU/FOP Rules) are to be equipped with ventilation of suction/exhaust type creating overpressure on the side of non-hazardous space or of a space with a lower explosion hazard.

Drop of the predetermined pressure in these spaces is to automatically actuate the fans.

3.3.1.2 The air inlet ducts passing through hazardous spaces are to be maintained in overpressure.

3.3.1.3 The hazardous spaces of Zone 1 are to be provided with ventilation with controlled capacity within a range from 10 to 20 air changes per hour.

At permissible gas concentration, the ventilation is to provide 10 air changes per hour. In case where gas concentration amounts to 20 ± 10 per cent of the lower explosive limit, the capacity of the ventilation is to be automatically increased to give up to 20 air changes per hour.

3.3.1.4 The hazardous spaces of Zone 2 are to be provided with ventilation providing at least 10 air changes per hour.

3.3.1.5 Exhaust ducts of Zone 1 spaces are to be separated from those of Zone 2 spaces. The internal spaces of such ducts like the spaces the ducts leave belong to the same zone.

Inlets of the suction type ventilation of hazardous spaces are to be arranged outside the hazardous areas. Outlet ends of ventilation ducts in hazardous spaces are to terminate in open areas of the same or lower explosion hazard.

3.3.1.6 Fans of non-sparking type are to be used in the ventilation system of hazardous spaces.

3.3.2 Sea water supply system of self-elevating MODU.

3.3.2.1 The equipment of the system is to include tanks for storage of sea water for cooling needs, (unless other method of cooling is provided) and to feed the fire extinguishing system. The cubic capacity of the tank intended for cooling is to be sufficient to meet the requirements of 3.2.3.2, and that of the tank intended for fire extinguishing is to be such as to ensure the operation of the installed water-based fire-extinguishing means as required in 3.2.7, Part VI "Fire Protection" of MODU/FOP Rules.

3.3.2.2 Appropriate measures are to be taken to prevent water freezing in tanks if it is necessitated by service conditions.

3.3.2.3 The system is to be served with not less than two submersible power-driven pumps. The capacity of any of these pumps is to be not less than that required to supply water for cooling and to water-based fire extinguishing system.

3.3.2.4 The design capacity of the pumps is to be ensured at all pump submersion depths possible during the operation.

3.3.2.5 Each sea water pump is to have its own suction protected from adverse effect of waves, ice and mechanical damage, provided with inlet screen and, if necessary, with heating arrangements.

3.3.2.6 The system is to be provided with measuring instruments and pressure alarms. Read-out facilities are to be fitted in the main machinery control room.

3.3.3 Hydraulic jacking system of MODU.

3.3.3.1 The hydraulic system of MODU is to meet the applicable requirements of Section 7, Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships.

3.3.3.2 The piping of hydraulic jacking mechanisms is not to communicate with other hydraulic systems.

3.3.3.3 In systems with considerable pressure surges, arrangements are to be provided to prevent pressure fluctuations.

3.3.3.4 The system is not to become inoperative on failure of one of the pumps.

3.3.3.5 Failure or damage of the hydraulic jacking mechanism pipes is not to result in spontaneous shifting of the MODU hull or legs by more than one step. The shifting speed is not to exceed the specified speed.

3.3.3.6 The working fluid used in the system is to retain its specified properties in all service conditions and is not to have harmful effect on the material of pipes and fittings.

3.3.3.7 Where any change in environmental temperature can have a marked influence on viscosity of the working fluid, arrangements are to be provided to prevent such influence in all specified temperature conditions.

3.3.3.8 The capacity of the working fluid tank of the hydraulic jacking mechanism of each leg is to be not less than that necessary for the total volume of working fluid filling the system.

3.3.3.9 The tanks of hydraulic drives are to be provided with low level alarms operating at the main control station.

3.3.3.10 The drainage pipes of the drip trays under the hydraulic equipment installed in spaces for hydraulic jacking mechanisms and tanks are to terminate in bilge tanks.

Pipes for collecting of leakage oil are to satisfy the requirements of 13.5, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

3.3.4 Fuel system for helicopters.

3.3.4.1 The fuel oil system for helicopters is to be arranged with due regard for the requirements of 2.3, Part VI "Fire Protection" of MODU/FOP Rules.

3.3.4.2 The fuel distribution stations are to be situated in open areas and are to be as remote from accommodation spaces and potential sources of ignition as practicable.

3.3.4.3 Tanks containing fuel for helicopters are to be provided with inert gas system and with a device to prevent inadmissible pressure fluctuations in the tanks in case of temperature variations and when the tanks are being filled or emptied.

3.3.4.4 Where changeable fuel containers are used, they are to be installed in such a way as to enable them to be dumped in case of emergency.

The design of the containers is to be approved by the Register.

3.3.5 Industrial piping.

The industrial and transportation pipelines which, in case when the MODU/FOP is used for its designated purpose, may contain dangerously explosive gases or flammable liquids are not to pass through accommodation and service spaces, control stations and machinery spaces, tanks and dry compartments.

3.3.6 Emergency mud dumping system.

3.3.6.1 The pipeline for emergency dumping of mud is to be equipped with two shut-off valves one of which is to be provided with position alarm monitored at the control station.

The valve closest to the mud tank is to be remotely operated from a readily accessible position above the bulkhead deck.

3.3.6.2 The pipeline for emergency dumping of mud is not to pass through the machinery, accommodation and service spaces.

3.3.6.3 The valves of the pipelines for emergency dumping of mud are to be installed with due regard for the requirements of 4.3.2.10, Part VIII "Systems and Piping" of the Rules for the Classification and Construction of Sea-Going Ships.

PART IX. BOILERS, HEAT EXCHANGERS AND PRESSURE VESSELS

1 APPLICATION

1.1 The requirements of the present Part of the Rules apply to boilers, heat exchangers and pressure vessels used to ensure operation of the systems and machinery serving the power plant and accommodation sector of the MODU or FOP.

1.2 Boilers, heat exchangers and pressure vessels intended for other purpose may comply with the requirements of MODU/FOP Rules in so much as practicable and reasonable.

2 GENERAL

2.1 The scope of supervision, materials used, strength of structural elements, welding and heat treatment, as well as the amount of testing of boilers, heat exchangers and pressure vessels mentioned in 1.1 are to comply with the requirements of Sections 1 and 2, Part X "Boilers, Heat Exchangers and Pressure Vessels" of the Rules for the Classification and Construction of Sea-Going Ships.

3 BOILERS

3.1 Steam boilers, as well as thermal oil boilers used on MODU and FOP, their burning installations, control, regulation and protection and alarm systems, fittings and gauges are to comply with the requirements of Sections 3 to 5, Part X "Boilers, Heat Exchangers and Pressure Vessels" of the Rules for the Classification and Construction of Sea-Going Ships.

3.2 On agreement with the Register, departures from the Rules mentioned in 2.1 may be permitted for boilers installed on the FOP.

4 HEAT EXCHANGERS AND PRESSURE VESSELS

4.1 Heat exchangers and pressure vessels are to comply with the requirements of Section 6, Part X "Boilers, Heat Exchangers and Pressure Vessels" of the Rules for the Classification and Construction of Sea-Going Ships.

4.1.1 Hydraulic accumulators.

4.1.1.1 The gas and liquid phases of the hydraulic accumulators are to be suitably separated in case where their direct contact can result in loss of the gas or spoilage of the liquid phase.

4.1.1.2 Each hydraulic accumulator is to be provided with a safety device fitted on the gas side. Such device may be fitted on the non-disconnectable portion of the pipeline.

4.1.1.3 Gas cylinders intended for filling of the hydraulic accumulators are to be manufactured to the standards approved by the Register.

PART X. ELECTRICAL EQUIPMENT

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements this Part apply to the electrical equipment of machinery installations (powerplants) as well as to systems and appliances of mobile offshore drilling units and fixed offshore platforms being subject to the technical supervision of the Register, and also to individual types of the electrical equipment according to 1.3.

1.1.2 The applicable requirements of this Part are also to be applied to the fixed electrical equipment not mentioned in 1.3, but potentially affecting the operation of essential machinery and appliances in case of their malfunctions or accidents.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations relating to the general terminology of the Rules are given in the General Regulations for the Classification and Other Activity.

For the purpose of this Part, the following definitions have been adopted.

Emergency lighting means lighting of MODU or FOP locations and spaces with lighting fixtures fed from an emergency source of power or from a temporary emergency source of power.

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

Emergency temporary source of electrical power is a source of electrical power intended to supply unit's necessary services from the moment of the voltage failure on the main switchboard busbars until the emergency source of electrical power is activated.

Safety voltage means any voltage non-dangerous for 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 those devices or sources of electrical power does not exceed 50 V between poles for direct current, or 50 V between phases or between phases and the unit's hull for alternating current.

Main machinery of MODU or FOP means the machinery intended to ensure the MODU or FOP performance of main industrial processes in accordance with its functional purpose.

Earthing means deliberate electrical connection of the part of the electrical equipment to be earthed to the unit's hull, which has a resistance not more than 0,2 ohm.

Enclosed spaces are locations limited by partititions and/or decks and bulkheads that may have doors or windows.

Lightning protection zone means the area within the limits of which the unit's space is protected against direct lightning strokes.

MODU or FOP hull means all the metal parts of a MODU or FOP having reliable electrical connection to an outer metal plating.

Lightning divertors is the upper part of the lightning protective system intended for the perception of atmospherics.

Minimum comfortable conditions of habitability on board the MODU or FOP are the conditions under which it is ensured the operation of electrical auxiliary machinery and arrangements for:

lighting;
cooking;
heating;
preservation of provisions (domestic refrigerating equipment);
forced ventilation systems;
sanitary water supply;
fresh water supply.

Non-essential services are the electrical equipment the temporary disconnection of which does not impair the level of MODU or FOP safety, the safety of people on board and environmental safety.

Main source of electrical power is a source of electrical power intended to supply all the electrical machinery, arrangements and systems necessary for maintaining the MODU or FOP in normal operational and habitable conditions without resorting to the emergency source of electrical power.

Essential services are the electrical equipment the normal operation of which ensures the safety of MODU or FOP operation, personnel on board and the environmental safety. These services include the ones listed in 1.3.2.1.

Semi-enclosed spaces are locations with natural ventilation conditions differing from those at the exposed decks due to such structures as partitions, wind deflectors and bulkheads arranged in the way that gas dispersion may not occur.

Control stations are rooms and spaces, which incorporate the following equipment and arrangements (as a complete or incomplete set):

control and normal shut-down systems for industrial process machinery and arrangements;

emergency shut-down systems for machinery and arrangements (including industrial machinery and arrangements);

control panel of the main source of electrical power;

control panel of auxiliary machinery and remote-controlled pipeline valves;

radiocommunication and intercommunication systems including a general alarm system;

main fire alarm station and an explosive gas concentration detection and alarm system;

remote control station of fire-smothering means;

direct control station of fire-smothering means;

control station of an emergency source of electrical power.

Special electrical rooms are locations intended expressly for electrical equipment and accessible to attending personnel only.

1.3 SCOPE OF SUPERVISION

1.3.1 General.

General provisions applicable to the classification procedure, supervision during MODU or FOP construction and equipment manufacture, and to surveys are stated in Part I "Classification" of MODU/FOP Rules.

1.3.2 Electrical equipment.

1.3.2.1 The following kinds of essential equipment, systems and arrangements are subject to supervision on board the MODU or FOP:

.1 electric propulsion plant of a self-propelled MODU, and electrical and electronic equipment of dynamic positioning systems;

.2 main, emergency and emergency temporary sources of electrical power, and also the sources of continuous electrical power supply for essential systems;

.3 power transformers and converters used in the equipment, systems and arrangements listed in 1.3.2.1;

.4 distribution boards, and control and monitoring desks and panels;

.5 electric drives of auxiliaries serving main machinery operation, drives of:

jacking arrangements of self-elevating MODU;

steering gear;

CP-propellers;

thrusters;

pumps of submersion and emersion systems of semi-submersible MODU;

submersible pumps of self-elevating MODU, and of arrangements for lifting sea water piping of those pumps;

anchor and mooring machinery;

launching devices for lifeboats and liferafts;

starting air, control system and sound signal air compressors;

bilge and ballast pumps;

pumps and arrangements of fire-extinguishing systems;

mechanisms of watertight and fire doors;

fans in machinery spaces, cofferdams, accommodation and service spaces;

fans in hazardous locations and spaces;

fans of equipment having the degree of protection as "pressurized enclosure";

.6 main and emergency lighting of spaces and locations of essential services, of escape routes, and low location emergency lighting;

.7 clearance, navigation and flashing lights;

.8 electric engine-room telegraphs of self-propelled MODU;

.9 service telephone and loud-speaking communication;

.10 general alarms;

.11 fire detection and alarm system, and a system warning of the release of fire-smothering medium; systems for detection and alarm of the high concentrations of explosive vapours and gases, of the malfunction of hazardous space ventilation systems and of pressurized electrical equipment, of the malfunction of self-elevating MODU jacking arrangements;

.12 indicating systems of the position of:

watertight and fire doors;

remote-controlled valves of MODU submersion and emersion systems;

self-elevating MODU legs on sea bed;

FOP base;

.13 electrical equipment in hazardous locations and spaces;

.14 cable network;

.15 MODU or FOP hull earthing facilities;

.16 lightning protection;

.17 electric drives of classified refrigerating machinery;

.18 electric fuel and oil heaters;

.19 stationary electrical heating and cooking appliances;

.20 starting equipment, protective devices, control gear and switchgear;

.21 other machinery and equipment not listed above as required by the Register.

1.3.2.2 The electrical equipment for domestic, living and industrial purposes and the electrical equipment of machinery, systems and arrangements directly intended for drilling wells and not listed in 1.3.2.1 is subject to supervision on board the MODU or FOP as to:

.1 the impact of this equipment operation on the performance of an electric generating plant;

.2 the choice of types and cross-sections of cables and wires, and also of ways of cabling;

.3 the resistance of insulation and protective devices.

In addition, the supervision is to be carried out in accordance with this part of the Rules with regard to fulfilment of the requirements on the explosion-proof type of electrical equipment in hazardous locations and spaces.

1.3.3 Supervision during manufacture of electrical equipment for MODU or FOP.

1.3.3.1 The following kinds of electrical equipment intended for use in installations and systems listed in 1.3.2.1 are subject to supervision during manufacture:

.1 generating sets;

.2 electric machines;

.3 transformers;

.4 switchboards;

.5 control and monitoring panels;

.6 electric couplings and brakes;

.7 starting, protective, control and switching devices;

.8 apparatus and devices of intercommunication and signalling;

.9 power converters, semiconductor installations;

.10 fuel oil and lubricating oil heaters;

.11 storage batteries;

.12 cables and wires;

.13 fixed electrical measuring instruments;

.14 electrical apparatus and facilities for measuring non-electrical parameters;

.15 heating and cooling appliances;

.16 wiring accessories;

.17 stationary lighting fixtures and searchlights;

.18 electrical equipment of dynamic positioning systems;

.19 other kinds of the electrical equipment not listed above as required by the Register.

1.3.3.2 The explosion-proof electrical equipment is to be supervised (as to its safety) by a special authority whose documents are recognized by the Register, irrespective of whether or not this equipment is subject to supervision according to the requirements of 1.3.3.1.

1.3.3.3 The scope and standards of electrical equipment tests after manufacture are subject to special consideration by the Register and the requirements for the tests are given in the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

1.4 TECHNICAL DOCUMENTATION

1.4.1 General provisions applicable to the procedure of technical documentation approval by the Register are set forth in the General Regulations for the Classification and Other Activity. The scope of technical documentation on electrical equipment for the entire unit to be submitted to the Register for consideration is stated in Part I "Classification" of MODU/FOP Rules.

1.4.2 Prior to the supervision of electrical equipment manufacture, the following documentation on each kind of equipment is to be submitted to the Register for consideration:

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

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

.3 general view drawings with sectional views;

.4 circuit diagrams;

.5 test program;

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

.7 busbar calculation for dynamic and thermal short circuit stability (for switchboards if the rated current of generators operating separately or the total current of generators operating in parallel exceeds 1000 A);

.8 data on dynamic and static interference immunity or method of electromagnetic compatibility testing;

.9 measures to be taken for interference suppression;

.10 drawings of electrical equipment layout in hazardous areas with indication of the kind of explosion protection, the type of used cables, their cross-sections and components of connection boxes;

.11 electrical diagrams of explosion-proof type equipment, diagrams of circuits relating to them, documentation witnessing the explosion protection type;

.12 drawings and specification of the electrical equipment having the explosion protection type "pressurized enclosure", an alarm system of excessive air pressure loss and the relevant diagrams.

2 GENERAL REQUIREMENTS

The electrical installation of a MODU or FOP is to be such as to ensure:

supply of all electrical machinery and arrangements maintaining normal operation of the MODU or FOP, including normal habitable conditions for personnel without the use of an emergency source of electrical power, from a main source of electrical power;

supply of essential services and arrangements, which ensure the MODU or FOP safety, from an emergency source of electrical power during the given period of time if a main source of electrical power fails;

the safety of the crew and installation as a whole under the conditions of MODU or FOP normal and emergency operation.

2.1 OPERATING CONDITIONS

2.1.1 Climatic conditions.

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

Table 2.1.1.1

Nos.	Equipment location	Ambient air and cooling water temperature, °C			
		Unrestricted area of navigation		Navigation outside the tropical zone	
		air	water	ir	water
1	Machinery and special electrical spaces, galleys	+45 — 0	+32	+40 — 0	+25
2	Service, accommodation and other spaces	+45 — 0	—	+40 — 0	—
3	Exposed decks	+45 — −25*	—	+40 — −25*	—

Notes: 1. Electric and electronic elements and devices designed for mounting in switchboards, panels and cabinets are to be capable of reliable performance at an ambient air temperature up to 55 °C. The temperature up to 70 °C is not to lead to the failure of the elements, devices and systems.

2.* The working temperature for electrical equipment installed on exposed decks is to be consistent with the MODU or FOP operational area.

2.1.1.2 Electrical equipment is to be capable of reliable performance at a relative air humidity of 75±3 per cent and a temperature of +45±2 °C or at a relative air humidity of 80±3 per cent and a temperature of +40±2 °C, and also at a relative air humidity of 95±3 per cent and a temperature of +25±2 °C.

The electrical equipment installed on MODU or FOP exposed decks when used in areas of a cold climate is to reliably operate at a relative air humidity of 85 per cent and a temperature of −6 °C.

2.1.1.3 The structural parts of electrical equipment are to be made of materials resistant to sea air or reliably protected against such effects.

2.1.1.4 Where the electrical equipment is installed in spaces or rooms protected against environmental effect, the ambient temperature allowable for such equipment may be reduced from 45 °C down to 35 °C, provided that:

the equipment is not an emergency one and is located outside machinery spaces;

the indoor temperature is controlled by at least two cooling units arranged in such a way that in case where one such unit fails, the remaining units are capable to maintain satisfactorily the prescribed temperature in the space;

the equipment is capable during the initial period to operate safely at ambient temperature of 45 °C until the ambient temperature reaches the prescribed value which is safe for the equipment. The cooling equipment itself is to be rated for the ambient temperature of 45 °C;

the permanently attended control stations are provided with audible and visible alarm to indicate faults in cooling units.

2.1.1.5 For the equipment with allowable ambient temperature less than 45 °C, provision is to be made that supply cables of such equipment were rated for the maximum ambient temperature which might be recorded (or expected) during installation over the whole length of cable.

2.1.1.6 The equipment installed for cooling and maintaining the lower ambient temperature (for the equipment specified in 2.1.1.4 and 2.1.1.5) is to be classified as an essential equipment and be subject to the Register technical supervision in compliance with the requirements of MODU/FOP Rules.

2.1.2 Mechanical effects.

2.1.2.1 Electrical equipment is to be capable of reliable operation at vibrations over the frequency range 2 to 80 Hz, namely: with the amplitude of displacements of ±1 mm for the frequency range 2 to 13,2 Hz and the acceleration ±0,7*g* for the frequency range 13,2 to 80 Hz. The electrical equipment mounted on the sources of vibration (diesel engines, compressors, etc.) or in the steering compartment of a MODU is to be capable of reliable operation at vibrations over the frequency range 2 to 100 Hz, namely: with the amplitude of displacements of $\pm 1,6$ mm for the frequency range 2 to 25 Hz and the acceleration $\pm 4,0g$ for the frequency range 25 to 100 Hz.

Electrical equipment is also to be capable of reliable operation at shocks having the acceleration $\pm 5,0$ g at the frequency of 40 to 80 shocks per minute.

2.1.2.2 Electrical equipment is to reliably operate:

semi-submersible MODU — at a continuous heel of up to 15° and at a short-term heel of up to 22,5° in any direction;

self-elevating MODU — at a continuous heel of up to 10° and at a short-term heel of up to 15° in any direction;

MODU — at a continuous heel of up to 15° and a trim by the bow or stern of up to 5°, and also in rolling up to 22,5° and heaving up to 7,5° out of the vertical.

In addition, emergency electrical equipment is to reliably operate:

semi-submersible MODU — at a continuous heel of up to 25° in any direction;

self-elevating MODU — at a continuous heel of up to 15° in any direction;

MODU — at a continuous heel of up to 22,5° and a trim of up to 10°, and also at a simultaneous heel and trim within the above limits.

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

2.1.3 Permissible variations of supply parameters.

2.1.3.1 Electrical equipment is to be so designed that it remains operative in all cases under steady conditions at all variations from the rated supply voltage and frequency as specified in Table 2.1.3.1 (see also 3.1.2.2 and 16.8.3.3).

Table 2.1.3.1

Electrical network parameter	Variations from rated values		
	Long-duration	Short-term	
	per cent	per cent	Process time, s
Voltage	+6 to −10	+20 to −20	1,5
Frequency	+5 to −5	+10 to −10	5

Note. If supplied by a storage battery:
Long-duration voltage variation within +30 per cent to -25 per cent for the equipment connected to the storage battery and not disconnected when the last is charged;
Long-duration voltage variation within +20 per cent to -25 per cent for the equipment disconnected from the battery

2.1.3.2 It is allowed to use the electrical equipment of the general industrial type not fully complying with the above requirements, what is subject to special consideration by the Register in each case, for machinery and arrangements on board the MODU or FOP other than the ones of essential services.

2.2 ELECTROMAGNETIC COMPATIBILITY

2.2.1 General.

2.2.1.1 These requirements apply to electrical, automation, radio and navigational equipment of a MODU or FOP to ensure electromagnetic compatibility of electrical and electronic equipment of the unit.

2.2.1.2 The equipment is to operate trouble-free under conditions of interference having the following parameters:

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

Table 2.2.1.2.1

Equipment class	Intensity, A/m	
	Constant field	Variable field (50 Hz)
1	100	10
2	400	400
3	1000	1000

It is allowed to install the equipment of:

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 any field source;

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

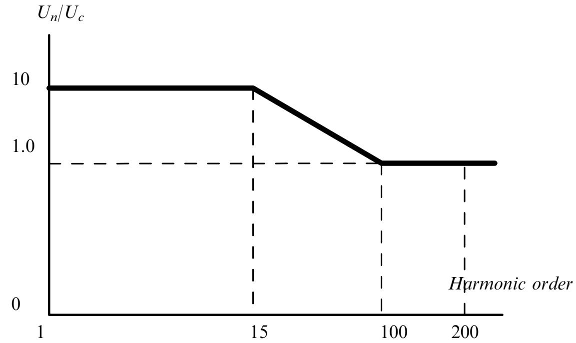


Fig. 2.2.1.2.2 Diagram of higher harmonics for mains

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

.4 radio frequency electromagnetic fields within the range 30 to 500 MHz with a root-mean-square value of field intensity of 10 V/m;

.5 nanosecond voltage pulses with an amplitude of 2 kV for the power supply circuits and of 1 kV for signal and control cables with the duration of 5/50 ns;

.6 radio frequency interference in conductivity circuits within the range 0,01 to 50 MHz with a root-mean-square value of voltage 1 V and 30 per cent modulation at the frequency of 1 MHz;

.7 microsecond voltage pulses in supply circuits with an amplitude of 1 kV for symmetrical pulse feed with the duration of 1,2/50 μs.

2.2.1.3 For a power supply circuit, the voltage harmonic distortion factor K_u is not to exceed 10 per cent and is determined by the formula

$$K_u = \frac{1}{U_c}\sqrt{\sum_{n=2}^{200} U_n^2} \times 100 \qquad (2.2.1.3)$$

where U_c = actual circuit voltage;
U_n = harmonic component voltage;
n = higher harmonic order.

The K_u value is specified for the complete electric power system.

On a special agreement with the Register, separate busbars with $K_u > 10$ per cent may be used for power supply to powerful sources of harmonic components of voltage and to the electrical equipment not sensitive to such harmonic components provided that the above busbars are connected to the main busbars through filtering or galvanic separation means (see also 2.2.2.2).

2.2.1.4 The intensity level of radio interference from the equipment at the electric power supply terminals is not to exceed the values shown in Fig. 2.2.1.4.

2.2.1.5 On board MODU or FOP for which the level of radio interference from power semiconductor converters cannot be limited in conformity with 2.2.1.4, the power supply of automation, radio and navigational equipment is to have a galvanic separation from the mains of those converters ensuring the attenuation of at least 40 dB within the frequency range 0,01 to 30 MHz.

The power supply cables of the equipment having the radio interference levels in excess of those specified in 2.2.1.4 are to be laid at least 0,2 m away

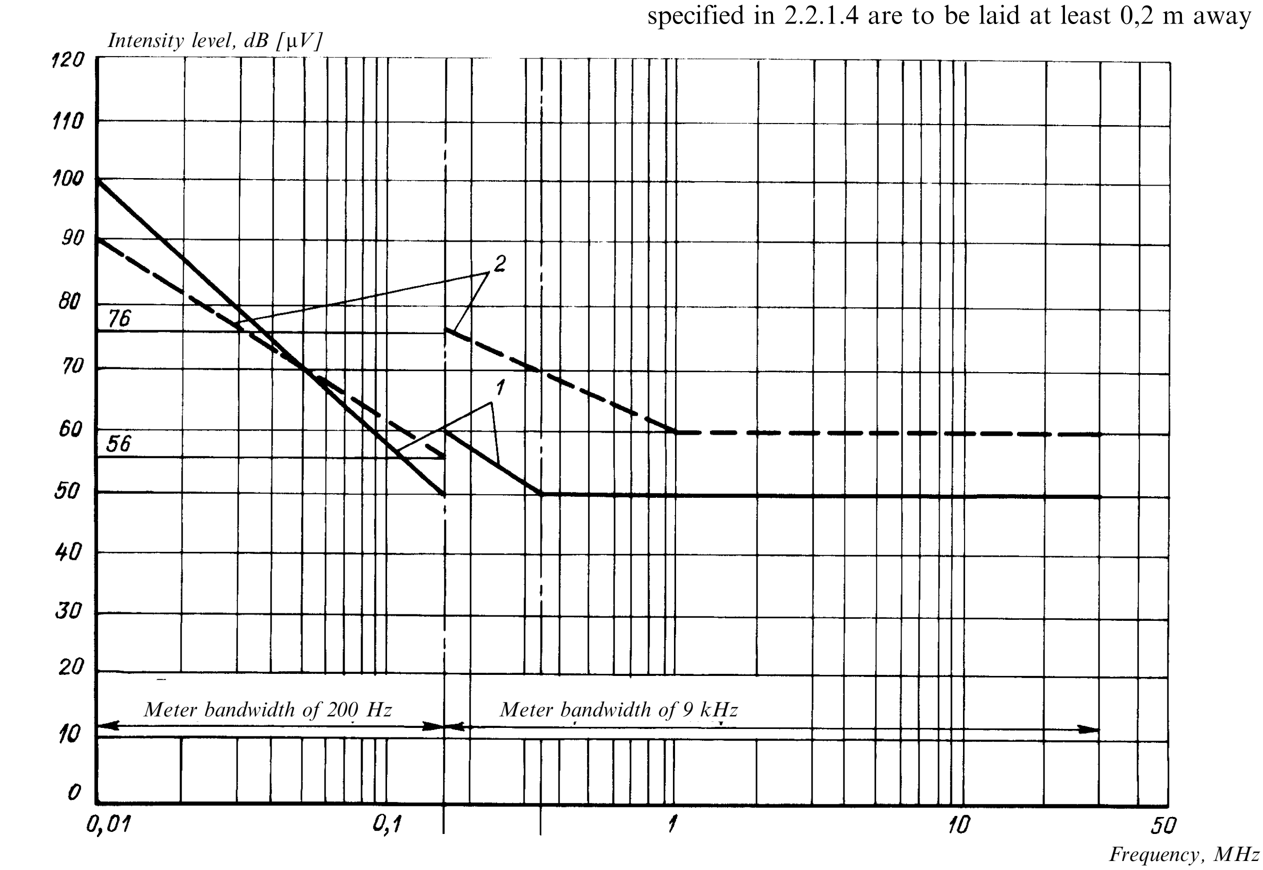


Fig. 2.2.1.4 Permissible levels of interference intensity
1 — from navigation and radio equipment as well as from electrical and automation equipment installed on the wheelhouse deck or above; *2* — from equipment installed below the wheelhouse deck

from the cables of other equipment groups where the common cable run is over 1 m (see also 2.2.2.8).

2.2.2 Measures ensuring electromagnetic compatibility.

2.2.2.1 To ensure the protection of radio equipment against electromagnetic interference, the requirements of Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships are to be taken into account.

2.2.2.2 To protect an electrical network against interference, interference suppression devices and galvanic separation means are to be used: filters, reactors, isolating transformers, rotary converters.

2.2.2.3 Power cable screens, metal sheath or armour are to be earthed by connection to the metal casing of equipment as frequently as possible, at each cable end as a minimum.

2.2.2.4 The screens of information signal cables and of control circuit cables are generally to be earthed at one end only on the side of the initial signal processing block. In this case, the cable is to have an external insulating coating.

2.2.2.5 Continuous screening is to be ensured in cable branch boxes and in cable distribution boxes and boards, and in way of cable penetrations through bulkheads by the connection of cable screens to earthed equipment housings.

2.2.2.6 The earthing of metal housings of electrical and electronic equipment is to have electric resistance not greater than 0,02 ohm, to be vibration- and corrosion-resistant, to have the minimum length possible and to be accessible for inspection.

2.2.2.7 Cable screens are not to be used as return conductors.

2.2.2.8 All information signal cables are to be screened and laid at a distance of at least 20 cm away from unscreened power cables and control circuit cables. For parallel laying, the above distance is to be increased up to 50 cm. Cables crossing is to be made at a right angle.

2.2.2.9 It is recommended to lay analog signal cables away from digital signal cables. Parallel laying of cables, which carry digital and analog signals, in one cable run is to be avoided. Where separate cable laying is impossible, the cables, which conduct analog low level signals, are to be laid in steel pipes or metal conduits (troughs) provided with current-conducting connections between themselves and the unit's hull. The cables of electroacoustic system circuits and similar to them are to be laid in metal pipes and away from other cables.

2.2.2.10 The entire cable network laid in the spaces in which the equipment of communication and radio navigation means is installed, as well as on the upper decks and superstructures not separated from aerials with a metal deck or bulkhead is made with screened cables observing screening continuity. When the supply cable of a radio equipment switchboard is led into a radio room, a radio interference filter is to be mounted at its entry.

2.2.2.11 The screens and housing of the electrical equipment in spaces with radio equipment are to be earthed. In accordance with 2.5.3.5, the screens of cables and wires are also to be earthed. The housing and screens of the electrical equipment may not be earthed provided it does not produce radio interference and not need protective earthing.

2.2.2.12 In the installation of electrical equipment and in cable laying near a magnetic compass as well as for protection of other navigational equipment, the requirements of Part V "Navigational Equipment" of MODU/FOP Rules are to be taken into account.

2.3 MATERIALS

2.3.1 Structural materials.

2.3.1.1 The structural parts of electrical equipment are to be manufactured of durable materials rated at least as flame-retardant, resistant to sea atmosphere, lubricating oil and fuel oil vapour effects or reliably protected against such effects.

2.3.1.2 Screws, nuts, hinges and similar items intended for securing enclosures of the electrical equipment installed on an exposed deck or in spaces with increased humidity are to be made of corrosion-resistant materials and/or to have effective corrosion-preventive coating.

2.3.1.3 All current-carrying parts of electrical equipment are to be made of copper, copper alloys or other materials of equivalent qualities with the exception of:

.1 rheostat elements which are to be made of mechanically durable materials having high resistivity and capable of withstanding high temperatures;

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

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

.4 elements of electrical equipment directly connected to the MODU or FOP hull and used as a return wire in a local single-wire system.

The use of other materials for current-carrying parts is subject, in each case, to special consideration by the Register.

2.3.2 Insulating materials.

2.3.2.1 Insulating materials of live parts are to have adequate dielectric strength and resistance to tracking, moisture and oil, as well as sufficient mechanical strength or to be properly protected. The heating temperature of current-carrying parts and their connections is not to exceed the permissible heating temperature of the insulating materials at the rated load.

2.3.2.2 Non-combustible liquids with the relevant insulating and heat-conducting characteristics 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 are to comply with the national agreed-upon 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 are to have insulation made of materials rated at least as flame-retardant, and for apparatus with increased heating and also for those specified in Section 15 — of non-combustible materials.

2.3.2.5 For insulating materials used for cable manufacture, see 16.3.

2.4 STRUCTURAL REQUIREMENTS AND PROTECTION OF ELECTRICAL EQUIPMENT

2.4.1 General.

2.4.1.1 Such parts which require replacement while in service are to be easily dismountable.

2.4.1.2 Where screw fastenings are employed, provisions are to be made for the prevention of self-loosening of screws and nuts, and of their loss in places of frequent dismantling or opening up.

2.4.1.3 Gaskets used in parts of electrical equipment (such as doors, covers, inspection holes, packing glands, etc.) are to ensure adequate protection when in service. Gaskets are to be secured to covers or casings.

2.4.1.4 Casings, panels and covers of electrical equipment installed in places accessible to unspecialized personnel are to be opened with tools or special keys only.

2.4.1.5 Suitable water drainage arrangements are to be provided in electrical equipment where condensation is likely to occur. Channels are to be provided inside the equipment to ensure the drainage of condensate from all equipment components. The windings and live parts are to be so arranged or protected that are not exposed to the effects of such condensate.

2.4.1.6 Electrical equipment with forced ventilation designed for installation in bottom parts of damp spaces is to be provided with such a ventilation system, which prevents the suction of moisture and oil vapours inside the equipment.

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

2.4.1.8 The portable standard electrical equipment for use in particularly damp locations and spaces is to be of the safety voltage type.

2.4.1.9 All electrical apparatus are to be so designed and installed that they cannot injure personnel in maintenance and if touched during normal operation.

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 are to be in conformity with the operating voltage and operating conditions of the installation taking into account the properties of the insulating materials in use.

2.4.3 Internal wiring.

2.4.3.1 Stranded wires are to be used for internal wiring of electrical equipment throughout. The use of solid wires is subject, in each case, to special consideration by the Register.

2.4.3.2 For internal wiring of switchgears, control desks and other distribution and switching arrangements, etc., wires of not less than 1 mm^2 in cross-sectional area are to be used. For systems of control, protection, measurement of different parameters, alarm and intercommunication, 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 less than 0,5 mm^2 in cross-sectional area may be used what is subject, in each case, to special consideration by the Register.

2.4.3.3 Current-carrying parts are to be so attached that they should not sustain any additional mechanical load; such parts are not to be attached with screws fitted directly into an insulating material.

2.4.3.4 The ends of multiwire strands of cables and wires are to be prepared in such a way as to suit the type of terminal used or to have cable lugs.

2.4.3.5 Insulated wires are to be laid and secured in such a way that insulation resistance does not reduce and they are not exposed to damages due to electrodynamic loads, vibration and shocks.

2.4.3.6 Arrangements are to be made to ensure that the temperature allowed for an insulated wire under normal operational conditions or for the duration of short-circuit current breaking is not exceeded.

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

2.4.4 Protection of electrical equipment enclosures.

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

2.4.4.2 The minimum protection of electrical equipment installed in MODU or FOP locations and spaces is to be selected according to Table 2.4.4.2.

2.4.4.3 Where liquid ingress onto electric panels of control and alarm systems or onto the like electrical equipment, which is necessary to ensure the safety of the unit, is likely to occur, such equipment is to have the enclosure protection at least IP23.

2.4.4.4 Additional requirements on the protection of electrical equipment with voltage above 1000 V are specified in Section 18.

2.5 PROTECTIVE EARTHING OF NON-CURRENT-CARRYING METAL PARTS OF ELECTRICAL EQUIPMENT

Metal housings of electrical equipment operating at a voltage in excess of the safety level and having no double or reinforced insulation are to be fitted with an earth terminal marked with a standard symbol.

Provision is to be made for earthing inside and outside of the electrical equipment housing depending on its purpose. Additional requirements for the earthing of equipment with voltage above 1000 V are specified in Section 18.

2.5.1 Parts to be earthed.

2.5.1.1 Metal parts of electrical equipment housings (enclosures) which are likely to be touched under operational conditions and which may become live in the event of insulation damage (except for those mentioned in 2.5.1.2) are to have a reliable electric contact with the MODU or FOP hull part fitted with an earth terminal (see also 2.5.3).

2.5.1.2 Protective earthing is not required for:

.1 electrical equipment supplied with current at a safety voltage;

.2 electrical equipment provided with double or reinforced insulation;

.3 metal parts of electrical equipment fastened in insulating material or passing therethrough and separated from earthed and live parts in such a way that those parts cannot become live or come in contact with earthed parts under normal operating conditions;

.4 housings of specially insulated bearings;

.5 lamp-holder caps and fasteners of luminescent lamps, lampshades, reflectors and housings attached

Table 2.4.4.2

Location of electrical equipment	Electrical equipment				
	Electrical machines, transformers	Switchboards, control gear, starters, control desks	Communication and alarm equipment, accessories (switches, sockets, joint boxes)	Space heating and cooking appliances	Lighting fixtures
Spaces and zones in which explosive mixtures of vapours, gases and dust with air are likely to occur	Ex (see. 2.11)	—	Ex (see. 2.11)	—	Ex (see. 2.11)
Dry spaces, dry accommodation	IP20	IP20	IP20	IP20	IP20
Navigating bridge, radio room	IP22	IP22	IP22	IP22	IP22
Service spaces, steering gear compartments, refrigerating plant rooms (except for ammonia equipment), emergency diesel generator room, general purpose stores, pantries, provision stores	IP22	IP22	IP22	IP22	IP22
Engine and boiler rooms:					
above plating	IP22	IP22	IP22	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,	IP44	IP44	IP55	IP44	IP44
laundries, bathrooms, showers	IP55	IP55	IP55	IP55	IP55
Working spaces, shafting	IP56	IP56	IP56	IP56	IP56
tunnels, cargo holds					
Exposed decks					

Note. Where the equipment enclosure does not ensure the necessary protection, alternative methods of protection or alternative equipment layout are to be applied to ensure the protection required.

to lamp-holders or lighting fixtures made of or screwed in an insulating material;

.6 cable fastenings;

.7 individual consumer with voltage up to 250 V supplied through an isolating transformer.

2.5.1.3 Shieldings and metal armour of cables are to be earthed.

2.5.1.4 Secondary windings of all instrument current and voltage transformers are to be earthed.

2.5.2 Earthing of structures on steel MODU or FOP.

2.5.2.1 Superstructures of aluminium alloys fastened to a steel hull but insulated therefrom, are to be earthed with at least two special wires, each having a cross-sectional area at least 16 mm^2, which do not give rise to electrolytic corrosion at the points of their connections to the superstructure and hull. Such earthing connections are to be provided at several places around the superstructure perimeter, to be accessible for inspection and protected against damages.

2.5.2.2 All stationary installed mechanical equipment, piping, metal structures of rigs, masts and helicopter platforms are to be reliably earthed if special conditions for mounting the above equipment or structures on board the MODU or FOP are not specified.

2.5.3 Earth terminals and conductors.

2.5.3.1 Earth conductors with a cross-sectional area above 4 mm^2 and up to 4 mm^2 are to be connected to the hull with bolts at least 6 mm and bolts 5 mm in diameter, respectively. For earth conductors with a cross-sectional area up to 2,5 mm^2, bolts 4 mm in diameter may be used. The bolts are not to be used for purposes other than earth conductors connection. The bolts screwed into the hull material without nuts are to be made of brass or other corrosion-resistant material.

The hull place of earth conductor connection is to be cleaned to metal and properly protected against corrosion.

2.5.3.2 Fixed electrical equipment is to be earthed by means of external earth conductors or an earthing core in the feeder cable. When earthing is effected with a special core of the feeder cable, it is to be connected to the earthing part inside the electrical equipment housing.

Such earthing effected with external earth conductors need not be provided in case the mounting of equipment ensures a reliable electrical contact between the equipment housing and the MODU or FOP hull under all operating conditions.

For earthing effected with an external earth conductors, the use is to be made of copper conductors. The conductors of other corrosion-resistant metal may also be used provided its resistance does not exceed that of the copper conductor required. The cross-sectional area of the copper earth conductor is not to be less than that specified in Table 2.5.3.2.

Table 2.5.3.2

Cross-sectional area of feeder cable core, mm^2	Cross-sectional area of earth conductor of fixed electrical equipment, mm^2, min	
	Solid	stranded
Up to 2,5	2,5	2,5
2,5 to 120	Half the cross-sectional area of feeder cable core, but not less than 4	
Over 120	70	

In case of earthing effected with the special core of the feeder cable, the cross-sectional area of that core is to be equal to the nominal cross-sectional area of the feeder cable core for cables having a cross-sectional area up to 16 mm^2, and at least half the cross-sectional area of the feeder cable core, but not less than 16 mm^2, for cables having a cross-sectional area over 16 mm^2.

2.5.3.3 Earthing of movable, detachable and portable consumers is to be effected through an earthed jack in the socket outlet or other earthed contact device and a copper earthing core of a flexible feeder cable. The cross-sectional area of the earthing core is not to be less than the nominal cross-sectional area of the flexible feeder cable core for cables having the cross-sectional area up to 16 mm^2, and at least half the cross-sectional area of the flexible feeder cable core, but not less than 16 mm^2, for cables having the cross-sectional area over 16 mm^2.

2.5.3.4 Equipment-earthing conductors and cores are to be non-disconnectable.

2.5.3.5 All metal cable shieldings and armour are to be electrically continuous and properly earthed.

Earthing of cable shieldings and armour is to be effected in one of the following ways:

.1 using a copper earth wire of a cross-sectional area at least 1,5 mm^2 for cables having the cross-sectional area of a core up to 25 mm^2 and not less than 4 mm^2 for cables having the cross-sectional area of a core over 25 mm^2;

.2 by suitable attachment of the shielding or metal armour to the MODU or FOP hull;

.3 by means of cable gland rings provided they are corrosion-resistant and good-conductive.

2.5.3.6 External earth conductors are to be accessible for inspection and protected against corrosion and mechanical damages.

2.6 LIGHTNING PROTECTION

2.6.1 General.

2.6.1.1 Each MODU or FOP is to be fitted with lightning protection devices whose protected zone is to cover all the equipment requiring lightning protection.

The MODU or FOP in which consequential effects of lightning strokes may cause fires and explosions, are to be fitted with lightning protection earthing devices to prevent potential consequential sparking.

2.6.1.2 A lightning conductor is to consist of an air termination, down conductor and earth termination. On metal masts, special lightning conductor need not be fitted if provision is made for reliable electrical connection of the mast to the MODU or FOP hull or earthing point.

2.6.1.3 Legs of arrangements for lifting and lowering columns of self-elevating units during towing operation, as well as after positioning, are to be earthed by bonding. This bonding is to be in compliance with the requirements of 2.6.3.1 and 2.6.3.2.

2.6.2 Lightning divertor.

2.6.2.1 The MODU or FOP vertically-extended structures (rigs, masts, derrick posts, superstructures, etc.) are to be used as an air termination if provision is made for reliable electrical connection of these structures to the metal hull.

Additional air terminations are to be used only in cases when the proper elements of the structure do not provide lightning protection.

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

2.6.2.3 The air termination is to 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, an aluminium rod is to be used.

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

2.6.3 Lightning conductor.

2.6.3.1 The down conductor is to be made of a rod, strip or multiwire cable having a cross-sectional area not less than 70 mm^2 for copper or its alloys, and not less than 100 mm^2 for steel. Steel down conductors are to be protected against corrosion.

2.6.3.2 Down conductors are to run on the outer side of masts and superstructures with the minimum number of bends, which are to be fair and have as large radius as practicable.

2.6.3.3 Down conductors are not to run through hazardous spaces and zones.

2.6.4 Earth termination network.

On MODU or FOP, any metal structures immersed in water under all operational conditions or having reliable electrical contact with sea water or sea bed may be used as an earth termination.

2.6.5 Connections in lightning conductor.

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

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

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

2.6.6 Lightning protection earthing devices.

2.6.6.1 Lightning protection earthing is to be provided for isolated metal structures, flexible connections, pipelines, screens of power and communication lines, and entry assemblies of hazardous spaces.

2.6.6.2 Petroleum product pipelines, and also all other piping associated with hazardous spaces and located on exposed parts of the deck or in spaces which are free from electromagnetic screening, are to be earthed to the hull not less than every 10 m lengthwise. The pipelines not associated with hazardous spaces and located on the deck where explosive gases are likely to appear, are to be earthed not less than every 30 m lengthwise.

2.6.6.3 Metal parts near to down conductors are to be earthed if they are not fixed to earthed structures or have no other metal contact with the MODU or FOP hull. Arrangements or metal parts located at a distance up to 200 mm from the down conductors are to be so connected to the down conductor that consequential sparking is excluded.

2.6.6.4 All joints of earthing elements are to be accessible for inspection and protected against mechanical damages.

2.7 ARRANGEMENT OF ELECTRICAL EQUIPMENT

2.7.1 Electrical equipment is to be installed so that controls and all parts being in need of maintenance, inspection and replacement are readily accessible.

2.7.2 Electrical machines are, where possible, to be installed so that MODU rolling effect along all axes is kept to a minimum. The design of electrical machine bearings and their lubrication system are to sustain the above rolling effects under storm conditions without disturbances and loss of lubricating oil, and to remain operational during the prolonged periods of time at the heel and trim specified in 2.1.2.2.

2.7.3 Essential electrical equipment on board each MODU or FOP, e.g. generators, main and other switchboards, electric motors and their starting apparatus are to be arranged and protected so that they remain operational in the event of emergency partial flooding of the machinery space with bilge water above the level of the upper boundary of tanks. The design limit of "partial flooding" is to be within the depth of water in a space equal to 1,5 m.

2.7.4 Electrical equipment is to be arranged in relation to a magnetic compass so that a magnetic effect during its switching-in or switching-off does not cause the compass deviation of more than 30″(0,05°).

2.7.5 Air-cooled electrical equipment is to be located so that cooling air is not taken from bilges or other spaces wherein the air may be contaminated with vapours or dust of substances having a harmful effect on insulation.

2.7.6 The electrical equipment placed in locations subject to vibrations and shocks (more heavy than those specified in 2.1.2.1) which are impossible to eliminate, is to be so designed as to ensure its normal operation under these conditions or to be mounted on relevant shock-absorbers.

2.7.7 Electrical equipment is to be fixed so that the strength of decks, bulkheads and hull plating does not reduce and their tightness is not impaired.

2.7.8 Open live parts of electrical equipment are not to be located closer than 300 mm horizontally and 1200 mm vertically to non-protected combustible materials.

2.7.9 Where the housings of electrical equipment are made of a different material than the structures on which they are installed, care is to be taken, if necessary, to prevent electrolytic corrosion.

2.8 SPECIAL ELECTRICAL ROOMS

2.8.1 The doors of special electrical rooms are to be locked and to open outward. Where the doors open into corridors and passageways in accommodation and service spaces, it is permitted that these doors open inward provided protection guards and stops are available. A warning notice is to be placed on the door. From the inside of the space, the door is to open without a key.

2.8.2 Special electrical rooms are not to be adjacent to the flammable liquid compartments and tanks. Where this requirement is not feasible from the structural point of view, measures are to be taken to prevent potential ingress of flammable liquids into these spaces.

2.8.3 No exits, pivoted side scuttles and other openings from special electrical spaces into hazardous spaces and zones are permitted.

2.8.4 Handrails of non-conducting material are to be fitted in special electrical spaces, passageways and servicing areas where the open-type electrical equipment is installed.

2.9 HAZARDOUS AREAS

2.9.1 Areas on board the MODU or FOP are divided into hazardous and non-hazardous in accordance with the requirements of 2.9.2 to 2.9.5.

Hazardous zones are enclosed spaces, semi-enclosed and out-door locations in which, due to presence of flammable gas/air mixture, explosion hazard exists continuously or periodically.

2.9.2 Hazardous areas are divided into zones as follows:

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 exist for a short time.

2.9.3 Zone "0" covers:

.1 internal spaces of closed tanks and pipelines relating to industrial components of the gas-saturated (active) drilling mud (i.e. the mud between a well mouth and a final degassing discharge) system, and internal spaces of oil and gas products tanks and pipelines, as well as other spaces in which an oil/gas/air mixture is continuously present or present for long periods;

.2 internal spaces of open industrial components from the surface of drilling mud to upper openings;

.3 internal spaces of vent pipes discharging oil/gas/air mixture from spaces specified in this paragraph.

2.9.4 Zone "1" covers:

.1 enclosed spaces containing any part of the gas-saturated (active) mud circulating system (e.g. between the wellhead and shale shaker) that is provided with releasable connections or open trough which are potential sources for release of oil-gas-air mixture;

.2 enclosed spaces or semi-enclosed locations that are below the drill floor and contain possible sources of oil/gas/air mixture release;

.3 enclosed spaces that are on the drill floor and are not separated by a solid gas-tight floor from the spaces specified in 2.9.4.2;

.4 the area within 1,5 m from the boundaries of any openings to the equipment which is a part of the gas-saturated mud system, in outdoor or semi-enclosed locations, except for those specified in 2.9.4.2, and also the area within 1,5 m from exhaust ventilation outlets of zone "1" spaces or from any other opening for access to zone "1";

.5 ducts, pits and other similar structures in locations which would otherwise be zone "2", but the removal of accumulated vapours and gases from them is impossible.

2.9.5 Zone "2" covers:

.1 enclosed spaces, which contain open sections of the mud circulating system from the final degassing discharge to the mud pump suction connection at the mud pit (degassed drilling mud);

.2 outdoor locations within the boundaries of the drilling derrick up to a height of 3 m above the drill floor;

.3 semi-enclosed locations below the drill floor and contiguous to the drilling derrick or beyond its boundaries to the extent of any enclosure (bulkhead) which is liable to trap gases;

.4 spherical outdoor locations below the drill floor and within a radius of 3 m from a potential source of oil/gas/air mixture release such as the top of a drilling nipple;

.5 the areas within 1,5 m beyond the zone "1" areas specified in 2.9.4.2 and 2.9.4.4;

.6 spherical outdoor spaces within a radius of 1,5 m from the boundaries of exhaust ventilation outlets or any other openings for access to locations and spaces of zone "2" from non-hazardous area;

.7 semi-enclosed drilling derricks to the extent of their enclosure above the drill floor or to a height of 3 m above the drill floor, whichever is greater;

.8 air-closed spaces (locks) between zone "1" and a non-hazardous area.

2.9.6 Other locations and spaces not associated with zones "0", "1" and "2" relate to non-hazardous locations and spaces.

2.9.7 The classification of locations and spaces by hazardous zones in accordance with 2.9.3 to 2.9.5 may, in each particular case, be changed on the Register requirement depending on the structural features of the unit and the conditions of locations and spaces ventilation.

2.9.8 The classification of locations and spaces not mentioned in 2.9.3 to 2.9.5, but which may, under certain conditions, become hazardous, by the relevant hazardous zones is, in each particular case, subject to special consideration by the Register.

2.10 OPENINGS, ACCESS AND VENTILATION CONDITIONS AFFECTING THE EXTENT OF HAZARDOUS AREAS

2.10.1 Except for operational reasons, access doors or other openings should not be provided between:

.1 non-hazardous and hazardous zones;

.2 hazardous spaces and locations of zone "2" and zone "1".

2.10.2 Where access doors or other openings are provided between spaces specified in the previous clause, the explosion hazard of any space with such openings is determined as follows:

.1 a non-hazardous space becomes hazardous of the same zone from where an access through doors or other openings is available;

.2 a hazardous space of zone "2" becomes a hazardous space of zone "1" except for cases specified in 2.10.3.

2.10.3 Enclosed spaces with direct access to zone "1" are considered as zone "2" if:

.1 the access is fitted with a gas-tight door that opens into the zone "2" space;

.2 ventilation is such that the air movement (flow) with the door open is from the hazardous zone "2" space into the zone "1" space;

.3 loss of ventilation is alarmed at a manned station.

2.10.4 Enclosed spaces with direct access to any zone "1" location are not considered hazardous if:

.1 the access is fitted with two self-closing gas-tight doors forming an air lock;

.2 the space has ventilation overpressure in relation to the hazardous location (space) of zone "1";

.3 loss of ventilation overpressure is alarmed at a manned station.

2.10.5 Enclosed spaces with direct access to hazardous zone "2" location are not considered hazardous if:

.1 the access is fitted with a self-closing gas-tight door that opens into the non-hazardous location;

.2 ventilation is such that the air movement (flow) with the door open is from the non-hazardous space into the zone "2" location;

.3 loss of ventilation is alarmed at a manned station.

2.10.6 Where a ventilation system, which ensures explosion proofness of a space, meets the requirements of MODU/FOP Rules to prevent any ingress of gases from zone "1" into it, the two doors forming an air lock may be replaced by a single self-closing gas-tight door that opens into the non-hazardous location.

2.10.7 No hold-back devices are permitted for self-closing doors.

2.10.8 All self-closing gas-tight doors are to have caution notes to the effect that the doors are to be closed at all times.

2.10.9 Piping systems are to be designed to preclude direct communication between hazardous areas of different classifications, and also between hazardous and non-hazardous areas.

2.11 ELECTRICAL EQUIPMENT AND CABLES IN HAZARDOUS ZONES

2.11.1 The requirements of this Chapter refer to the equipment installed in hazardous enclosed spaces and semi-enclosed locations relating to hazardous zones "0", "1" and "2".

These spaces include storerooms for volatile flammable substances, battery rooms and spaces containing tanks, machinery and piping for flammable liquids with a vapour flashpoint 60 °C and less.

2.11.2 Electrical equipment installed in hazardous zones is to be certified as to its hazard irrespective whether the above equipment is subject to the Register technical supervision according to the requirements of 1.3.3.1.

Certification determining the explosion protection type of the electrical equipment is to be carried out by competent independent bodies, the documents (certificates) of which are recognized by the Register.

2.11.3 In hazardous spaces and areas, it is permitted to install only explosion-proof electrical equipment of the explosion protection type that is consistent with the category and group of the most hazardous gas mixture which may be present at the place of installation.

2.11.4 In spaces of hazardous zone "0", certified electrical equipment and cables only of the explosion protection type "intrinsically safe electric circuit" (Exia) may be installed.

2.11.5 In locations and spaces of zone "1", certified electrical equipment of the following explosion protection types may be installed:

.1 "intrinsically safe electric circuit" (Exia, Exib)

.2 "flameproof enclosure" (Exd);

.3 "increased safety" (Exe);

.4 "special protection type" (Exs);

.5 "pressurized enclosure" (Exp).

2.11.6 In locations and spaces of zone "2", certified electrical equipment of the following types may be installed:

.1 listed in 2.11.5;

.2 non-explosion-proof equipment with the IP55 and over type enclosure, which ensures absence of sparks and arcs, and has no surfaces, heated over 80 °C during normal operation.

2.11.7 Electrical equipment installed in hazardous zone "2" and also outside hazardous zones but intended for operation in emergency (e.g., in cases of uncontrolled well manifestation resulting in extension of hazardous zones) is to be of explosion-proof type required for zone "1".

2.11.8 Explosion-proof lighting fixtures are to be installed so that clear space, except for the place of fastening, of at least 100 mm wide remains around them.

2.11.9 Fastening of electrical equipment immediately to surfaces of combustible liquid tanks is not permitted. In any case, the electrical equipment is to be fastened at a distance of at least 75 mm from the tank surfaces.

2.11.10 In hazardous zones, the cables of the following types may be laid:

.1 In hazardous zone "0": cable types specially intended for implementation of "intrinsically safe electric circuit".

.2 In hazardous zone "1", all cables are to have:

a non-metallic impervious outer sheath over a screening or protective metallic braid;

a non-metallic impervious outer sheath and the copper one (for mineral-insulated cables).

.3 In hazardous zone "2", all cables are to have:

sheaths as specified for zone "1";

a non-metallic outer sheath without a metallic screening or protective braid provided relevant protection against mechanical damages is ensured.

2.11.11 In hazardous locations and spaces, cables intended only for the electrical equipment installed in those locations and spaces may be laid. Through cables via the above locations and spaces may be laid provided the requirements of 2.11.10 are met.

2.11.12 All shields, and also metallic braids of cables of supply circuits for electric motors and lighting circuits, which pass through hazardous locations and spaces or supply electrical equipment installed in these, are to be earthed at least at both ends.

2.11.13 Intrinsically safe circuit cables may be used for one device only and are to be laid separately from other cables.

Cables of portable electrical devices, except for intrinsically safe circuit cables, are not to pass through hazardous locations and spaces.

In paint lockers and ventilation ducts serving these spaces it is permitted to install only that electrical equipment which is necessary for serving the given space. This electrical equipment is to be explosion-proof of the type:

.1 intrinsically safe electric circuit (Exi);

.2 with pressurized enclosure (Exp);

.3 with flameproof enclosure (Exd);

.4 increased safety (Exe);

.5 special protection type (Exs).

2.11.14 The minimum requirements for electrical equipment by the explosion protection type are to be consistent with the gas mixture category IIB and gas mixture group T3.

2.11.15 Enclosed spaces giving access to paint lockers may be considered as non-hazardous provided that:

.1 the door into the paint locker is gas-tight, self-closing and has no hold-back device;

.2 the paint lockers are provided with an independent exhaust ventilation system and/or with a supply ventilation system having air intake from places located outside hazardous areas; ventilation system switching-off is alarmed at a manned station;

.3 caution-notes are fitted at the entrance stating that the locker contains flammable liquids.

2.12 ANTISTATIC EARTHING

2.12.1 Antistatic earthing is a mandatory means of ensuring electrostatic intrinsic safety for all types of MODU and FOP having hazardous spaces and zones.

2.12.2 Stationary and portable equipment installed in enclosed and semi-enclosed spaces and zones, in which explosive mixtures of vapors, gases or dust with air are likely to occur, is to have antistatic earthing.

2.12.3 At all entrances to hazardous spaces and zones conditions are to be provided to remove electrostatic charge from people entering those spaces and zones through installation of metal earthed plates, handrails or handles to remove charge when touched with the hand or by placing wet mats (rugs) at entry.

2.12.4 The following equipment does not require use of antistatic earthing:

.1 electrical equipment (including portable one) 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 electro-radio-navigational equipment earthed in accordance with 2.2.2;

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

2.12.5 Arrangement and monitoring of antistatic earthing.

2.12.5.1 Unless otherwise specified, the design of the antistatic earthing conductors is to comply with the requirements of 2.5. The method of connecting antistatic earthing conductors to non-metal equipment or plastic piping is to be specified by the equipment manufacturer.

2.12.5.2 Design of the antistatic earthing conductors is to meet the requirements of the present Chapter and standards approved by Register.

2.12.5.3 The resistance value measured between the equipment (component, structure) and MODU (FOP) hull is not to exceed 10^6 Ohm with the area of contact between measure electrode and the equipment surface being no more than 20 mm^2. Resistance of the antistatic earthing is to be monitored by a measuring device (ohmmeter) with control d.c. voltage of not more than 10 V.

3 MAIN SOURCE OF ELECTRICAL POWER

3.1 COMPOSITION AND CAPACITY OF MAIN SOURCE OF ELECTRICAL POWER

3.1.1 Every MODU or FOP is to be provided with a main source of electrical power whose capacity is sufficient to supply all MODU or FOP necessary electrical equipment under conditions specified in 3.1.4. Such a source is to consist of at least two independently-driven generators.

3.1.2 The number and capacity of independently-driven generators, and also of transformers and electric converters which the main source of electrical power includes, are to be such that if any of them fails, the rest would ensure:

.1 supply of the necessary electrical equipment under conditions specified in 3.1.4 with simultaneous ensuring the minimum comfortable conditions of habitability for all personnel on board the MODU or FOP;

.2 start of the most powerful electric motor with the greatest starting current. In this case, the motor start is not to involve a voltage and frequency drop in the mains that could result in the drop out of synchronism, the stop of generator prime mover and also in the disconnection of operating machinery and apparatus;

.3 supply of industrial machinery and components; if cut, it may result in emergency situations on board the MODU or FOP and in hazard for personnel;

.4 supply of an electrical propulsion installation and/or electric units of the MODU dynamic positioning system. For that purpose, an emergency source of electrical power may be used if its capacity or in association with the capacity of any other electrical power source ensures the simultaneous supply of emergency consumers specified in 9.3.

3.1.3 Given the proper redundancy and layout of main source units on board the MODU or FOP which prevent their simultaneous failure, and also their adequate capacity, it is permitted to use a common electric power plant for supply of essential consumers specified in 1.3.2, an electrical propulsion plant, a dynamic positioning system and industrial machinery and components.

3.1.4 The number and capacity of electrical units of the main source are to be determined with regard to the following modes of MODU and FOP operation:

.1 transit conditions and/or maneuvering (for MODU);

.2 drilling of borehole;

.3 production and pumping of oil/gas products into a tanker;

.4 emergency operations, e.g. fire, flooding or others affecting MODU or FOP safety emergency conditions;

.5 other modes appropriate for the MODU or FOP design and purpose.

3.1.5 Supply of industrial machinery and components may be effected from the separate source of electrical power.

3.2 GENERATING SETS

3.2.1 General.

3.2.1.1 Prime movers of generators are to meet the requirements of Section 3, Part VII "Machinery Installations" of MODU/FOP Rules and the additional requirements of this Chapter.

3.2.1.2 At short circuits in a network, the generators are to ensure the value of a steady short-circuit current sufficient for the actuation of protective devices.

3.2.1.3 Voltage and frequency regulation for independently-driven generators is to be ensured within the ranges specified respectively in 10.5 and 10.6, and in Section 3, Part VII "Machinery Installations" of MODU/FOP Rules.

3.2.1.4 The deviation from sine voltage for alternators is not to be over 5 per cent of the first-harmonic peak value.

3.2.2 Load sharing between sets running in parallel.

3.2.2.1 Alternating-current generating sets intended to run in parallel are to be provided with such a reactive-voltage 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 per cent of the rated reactive load of the largest generator involved or by not more than 25 per cent 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 per cent of the total load, generator currents may deviate within ± 15 per cent from the rated current value of the largest generator.

3.3 NUMBER AND CAPACITY OF TRANSFORMERS

2.3.1 On MODU or FOP, where transformers powered from a shore-based network are used as the sets of the main source of electrical power, and also where lighting and other essential services are powered through transformers, at least two transformers are to be provided of such a capacity that if the largest one fails, the others can satisfy the total demand for electrical power under all operating conditions of the MODU or FOP.

Transformers are to be connected to different sections of the main switchboard.

3.4 POWER SUPPLY FROM AN EXTERNAL SOURCE OF ELECTRICAL POWER

3.4.1 If provision is made for MODU or FOP mains to be supplied from an external source of electrical power, an external supply switchboard is to be provided (see also 4.5.4.5).

3.4.2 At the external supply switchboard, the following facilities are to be provided;

.1 terminals for flexible cable connections;

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

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

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

.5 plate indicating voltage, the type of current and frequency;

.6 arrangement for mechanical fastening of the end of a flexible cable connected to the switchboard and of a hanger for a cable, which are both to be arranged on the external supply switchboard or near it.

3.5 CONNECTION OF UNITS OF MAIN SOURCE OF ELECTRICAL POWER

3.5.1 The units of the main source of electrical power are to be tailored for lengthy operation in parallel to feed common busbars. In this case, the diagram of connections used is to ensure their switching-on for parallel operation at any time for load transfer from one unit to another.

3.5.2 Where provisions are made for an automatic synchronization system, the necessary instruments and means to ensure standby manual synchronization are to be provided on the main switchboard.

3.5.3 Where required for initial excitation, a magnetizing device is to be fitted on the main switchboard for synchronous alternating-current generators.

3.5.4 Where its own main units and external sources of electrical power are not intended to operate in parallel to the common busbars of the electrical installation, the system of connections, in this case, is to be so interlocked as to prevent their possible switching-on for parallel operation.

3.5.5 Disconnecting devices for disconnection of a collecting busbars system are to be fitted on the main switchboards intended for distribution of electrical power of generators operating in parallel. Consumers and generators, where possible, are to be symmetrically distributed among all collecting busbar systems.

Main switchboard busbars disconnecting devices may be:

circuit breaker without tripping mechanism, or

disconnecting link or switch by which busbars can be connected or disconnected easily and quickly.

Bolted links, for example bolted busbar sections, are not acceptable.

3.5.6 Under normal operational conditions, provision is to be made, as a rule, for supply of an emergency switchboard, i.e. of an emergency supply system for the MODU or FOP essential consumers, from the main switchboard.

3.6 UNINTERRUPTIBLE POWER SUPPLY (UPS)

3.6.1 Uninterruptible power supplies (UPS), in addition to the below requirements, are to comply with IEC 62040 standard and applicable requirements of national standards.

3.6.2 UPS complying with the present requirements may be used as emergency or transitional sources of power required by Section 9.

3.6.3 The type of UPS is to be appropriate to power supply requirements of the connected load equipment.

3.6.4 UPS are to be provided with a bypass ensuring power supply to connected load from the ship's mains if the inverter fails.

3.6.5 Each UPS is to be provided with audible and visual alarm to be given in normally attended location for:

power supply failure to the connected load;

earth fault;

operation of accumulator battery protective device;

accumulator battery is being discharged;

bypass operation for permanent on-line UPS.

3.6.6 Requirements for UPS arrangement are to be similar to the requirements for arrangement of the emergency or transitional source of electrical power.

3.6.7 UPS with sealed-in accumulator batteries may be arranged at any spaces except for accommodation spaces, where sufficient ventilation is provided.

3.6.8 UPS is to maintain rated voltage and frequency on the load side throughout the whole time necessary to supply the connected consumers.

3.6.9 On restoration of the voltage in the supply circuit, the USP rectifier capacity is to be sufficient to maintain rated voltage and frequency on the load side with simultaneous recharging the battery by maximum possible charging current.

3.6.10 The accelerated charging of the UPS accumulator batteries by the maximum possible charging current is to be interlocked with the ventilation of the space where the UPS batteries are installed.

4 DISTRIBUTION OF ELECTRICAL POWER

4.1 DISTRIBUTION SYSTEMS AND PERMISSIBLE VOLTAGE

4.1.1 The following systems of electrical power distribution may be used on board the MODU and FOP:

.1 for alternating current over 1000 V (up to 15000 V inclusive) — 50 Hz or 60 Hz:

three-phase three-wire insulated system;

three-phase three-wire insulated system with the zero point earthed via a high-value resistor or reactor.

.2 for alternating current up to 1000 V — 50 Hz or 60 Hz:

three-phase three-wire insulated system;

three-phase three-wire insulated system with the zero point earthed via a high-value resistor or reactor;

.3 for alternating current up to 500 V inclusive — 50 Hz or 60 Hz:

.3.1 as specified in 4.1.1.2;

.3.2 three-phase four-wire insulated system;

.3.3 single-phase two-wire insulated system;

single-phase single-wire system with the unit's hull return for voltage up to 30 V only, except for a supply system of navigation lights, provided that any possible current will not pass directly through any of hazardous spaces;

.4 for direct current up to 1000 V:

two-wire insulated system;

single-wire (only for voltage up to 50 V for local earthed systems, e.g. for starter systems of internal combustion engines) system with the unit's hull return, provided that any possible current will not pass directly through any of hazardous spaces.

The use of other distribution systems is subject, in each case, to special consideration by the Register. (See also 18.2).

4.1.2 Every insulated distribution system, irrespective of whether it is primary or secondary, power, lighting or heating one, is to be provided with audible and visual alarms actuated on the drop of insulation resistance below the set level.

4.1.3 Permissible voltage across the terminals of sources of electrical power with frequency of 50 Hz or 60 Hz is not to exceed the values specified in 4.1.1 depending on the electrical power distribution system adopted.

4.1.4 Permissible voltage across the terminals of direct current sources is not to exceed the following values:

500 V for power systems;

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

4.1.5 Permissible voltage across the terminals of consumers is not to exceed the values specified in Table 4.1.5.

Additional requirements for networks for voltage over 1000 V are specified in Section 18.

4.2 POWER SUPPLY OF ESSENTIAL SERVICES

4.2.1 The following consumers relating to essential ones are to be supplied by separate feeders from the main switchboard busbars:

.1 electric drives of MODU steering gears and anchor arrangements;

.2 electric drives of fire pumps, sprinkler system pumps and compressors;

.3 bilge pump electric drives;

.4 electric drives of the machinery serving main machinery operation;

.5 switchboards of electric drives for cargo, mooring, lifeboat and other essential services intended for life-saving appliances and personnel evacuation;

.6 electric drives of jacking system machinery of self-elevating MODU, and of submersion and raising systems of semi-submersible MODU;

.7 electric drives of hazardous location and space fans, of fans for equipment with the explosion protection type "pressurized enclosure";

.8 electric drives of the machinery supporting industrial machinery and components (i.e. machinery intended for performance of MODU or FOP main functions);

.9 electric drives of exciter sets of the MODU electrical propulsion installation or the unit as a whole;

.10 dynamic positioning systems equipment (thrusters and their control systems);

.11 emergency switchboard under normal conditions of MODU or FOP operation;

.12 gyrocompass (from an uninterruptible power supply system);

.13 main lighting system (via appropriate transformer equipment);

Table 2.4.4.2

Nos	Consumers	Permissible voltage, V
	Alternating current	
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, cooking and heating appliances installed in cabins, mess-rooms and other similar spaces for personnel	500
3	Lighting, alarms, intercommunication, socket outlets for supply of portable consumers with double or reinforced insulation or isolated electrically by means of an isolating transformer	250
4	Socket outlets fitted in locations and spaces with elevated humidity or in extra humid spaces, and intended for supply of portable consumers having no double or reinforced insulation, or not isolated electrically	50
	Direct current	
5	Fixed power consumers	500
6	Heating, cooking, etc, appliances	250
7	Lighting, socket outlets	250

Note. In spaces with elevated humidity and in extra humid spaces, notices are to be provided at socket outlets with voltage above the safety one to notify of the use of consumers with double or reinforced insulation or of those electrically isolated from overrating voltage.

.14 radio station switchboard (from an uninterruptible power supply system);

.15 navigational equipment switchboard (from an uninterruptible power supply system);

.16 switchboard of navigation lights and warning flashing lanterns, and switchboard of electrical sound signal devices (from an uninterruptible power supply system);

.17 section switchboards and switchgears for supplying other essential consumers combined on the principle of homogeneity of their functions;

.18 switchgears of an integrated bridge control console (see also 4.4);

.19 switchboard of an automatic fire detection and fire alarm system, and of a warning alarm of fire-smothering medium release (from an uninterruptible power supply system);

.20 charging facilities of starter accumulator batteries and batteries supplying essential services and relating to an uninterruptible power supply system;

.21 switchboards of electric drives for closing of watertight doors, and of devices holding fire doors in open position, and also switchboards of the alarm of watertight and fire doors position and closure (from an uninterruptible power supply system);

.22 switchboard of a refrigerating plant for a low-pressure carbon dioxide smothering system;

.23 lighting switchboards for hangars and helicopter deck illumination;

.24 other consumers not listed above as required by the Register.

4.2.2 Where one-purpose machinery with electric drives specified in 4.2.1 is installed in double or greater number, at least one of those electric drives is to be supplied by a separate feeder from the main switchboard. Electric drives of the rest of such machinery may be supplied from section switchboards or from special switchboards intended for supply of essential consumers.

4.2.3 Electric drives, section switchboards, special switchgears or boards installed in double or greater number or supplied by two feeders are to be connected to different sections of the main switchboard (see 3.5.5).

4.3 POWER SUPPLY OF ELECTRICAL AND ELECTRONIC AUTOMATION SYSTEMS

4.3.1 Power supply of electrical and electronic automation systems is to meet the requirements of Section 3, Part XIV "Automation" of MODU/FOP Rules.

4.3.2 Power supply of automation devices necessary for starting and operating an emergency diesel-generator is to be effected from a starter battery or another independent accumulator battery located in the emergency diesel-generator space.

4.4 POWER SUPPLY OF INTEGRATED BRIDGE CONTROL CONSOLE

4.4.1 Switchgears of an integrated bridge control console are to be supplied from the main switchboards directly or via transformers by two independent feeders connected to different sections of the main switchboard busbars, or by one feeder from the main switchboard or from the emergency switchboard.

4.4.2 Switchgears of an integrated bridge control console are to be independently supplied by a separate feeder from other source or sources of power as well, where necessary, basing on the requirements for the equipment fed from those switchgears, or according to other technical reasons.

4.4.3 A switchgear is to be provided with a change-over switch for feeders.

Where an automatic change-over switch is used, manual switching-over of feeders is also to be ensured. In this case, provision is to be made for necessary interlocking.

4.4.4 Each consumer specially listed in 4.2.1 fed from switchgears of an integrated bridge control console is to be supplied by a separate feeder.

4.4.5 A visual alarm of presence of supply voltage in each potential feeder is to be fitted in an integrated bridge control console.

4.5 SWITCHBOARDS AND SWITCHGEARS

4.5.1 Switchboard design.

4.5.1.1 Frames, front panels and enclosures of main, emergency, section and distribution switchboards are to be made of metal or some other durable non-combustible material. Generator sections of the main switchboard are to be separated from each other or from other sections with non-combustible bulkheads preventing spread of sparks and flame.

4.5.1.2 Switchboards are to have a sufficiently rigid structure, which can withstand mechanical stresses liable to occur under operational conditions or due to short circuits.

4.5.1.3 Switchboards are, at least, to be protected against drip. This protection is not required if the switchboards are to be located in spaces where vertically falling drops of liquid can not get into the switchboard.

4.5.1.4 Switchboards to be installed in locations accessible to unauthorized persons are to be provided with doors being opened with a special key, which is the same for all the switchboards on board a MODU or FOP.

4.5.1.5 The design of switchboard doors is to be such that with the doors opened, access to all parts needing maintenance is ensured, and the live parts fitted on the doors are to be protected against inadvertent touching.

Opening panels and doors used for mounting electrical control gear and measuring instruments are to be securely earthed with at least one flexible jumper. Where the opening parts of switchboards are made of dielectric material, the gears and instruments are to be earthed.

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

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

4.5.1.7 The generator panels of main switchboards are to be illuminated with lighting fixtures supplied on the generator side before the main breaker of the generator or not less than from two different systems of busbars.

4.5.1.8 The lighting of the front side of switchboard panels is not to interfere with instrument observation or produce a blinding effect.

4.5.1.9 The design of switchboards, which have no space at the rear is to be such that the access to all parts requiring maintenance is ensured.

Arrangements are to be provided for doors of switchboards and distribution cabinets to fix them in the open position. Withdrawable blocks and instruments are to be fitted with devices preventing their fall-out when withdrawn.

4.5.1.10 Each switchgear designed for voltage over the safety one, with switching and protective devices and not fitted with a voltmeter, is to be provided with a pilot lamp indicating the presence of voltage on busbars.

4.5.2 Busbars and uninsulated conductors.

4.5.2.1 The ultimate heating temperature of switchboard busbars and uninsulated conductors at the rated load and short circuit or at the permissible one-second short-circuit load for copper busbars is to be determined according to national standards.

4.5.2.2 Equalizer busbars are to be designed for at least 50 per cent of the rated current of the largest generator connected to the main switchboard.

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

4.5.2.4 Busbars and uninsulated conductors in switchgears are to have electrodynamic and thermal stability during short-circuit currents occurring at relevant points in the circuit. Electrodynamic loads as occur in busbars and uninsulated conductors due to short circuit are to be determined according to national standards.

4.5.2.5 Insulators and other parts for fastening busbars and uninsulated conductors are to withstand loads due to short circuits.

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

4.5.2.7 Busbars and uninsulated conductors of different polarity are to be marked with the following distinctive colours:

red for positive pole;

blue for negative pole;

black or green and yellow (cross stripes) for earth connections;

light blue for middle wire.

The equalizer connection is to be marked with white cross stripes in addition to the appropriate colour as given above.

4.5.2.8 Busbars and uninsulated conductors of different phases are to be marked with the following distinctive colours:

yellow for phase 1;

green for phase 2;

violet for phase 3;

light blue for neutral wire;

green and yellow (cross stripes) for earth connections.

4.5.2.9 Busbars are to be connected so as to prevent corrosion in way of their connections.

4.5.3 Calculation of short-circuit currents and selection of switch apparatus.

4.5.3.1 Electrical switch apparatus are, at least, to comply with national standards and to be so selected that:

under normal operational conditions their rated voltages, currents and temperature rise limits are not exceeded;

they are capable of withstanding, without damage or exceeding temperature limits, such overloads as specified for transient conditions;

their characteristics under short-circuit conditions are consistent with the actual short-circuit power factor as well as with the behavior of the subtransient and transient short-circuit current.

4.5.3.2 The rated breaking capacity of electrical switch apparatus designed to break short-circuit currents is not to be less than the prospective short-circuit current at the point of their installation at the moment of breaking.

4.5.3.3 The rated making capacity of circuit breakers and switches which may be incorporated in a shorted electric circuit is to be not less than the prospective maximum making current under short-circuit condition at the point of their installation.

4.5.3.4 The electrodynamic ability current of electrical apparatus not intended for interrupting short-circuit currents is not to be less than the prospective peak short-circuit current at the point of their installation.

4.5.3.5 The thermal strength of apparatus is to be consistent with the prospective short-circuit current at the moment of breaking at the points of their installation taking into account the expected duration of short circuit based on the selective action of the protection.

4.5.3.6 The use of a circuit-breaker with an inadequate breaking and/or making capacity relative to the prospective peak short-circuit current at the point of its installation is admissible, provided that it is protected on the generator side by means of fuses and/or a circuit breaker with, at least, necessary ratings for short-circuit currents which is not used as a generator switching device.

The characteristics of the arrangement thus composed are to be such that:

.1 while breaking the prospective peak short-circuit current, the circuit breaker on the load side will not be so damaged as to become unfit for further service;

.2 making the circuit breaker on the prospective peak short-circuit current will not result in damage to the remaining part of the electrical installation; in this case, it is allowed for the circuit breaker on the load side not to be immediately fit for further service.

4.5.3.7 In electric circuits having a current rating in excess of 320 A, circuit breakers are to be fitted for overload protection.

4.5.3.8 In direct current compound generator circuits, where the generators are intended for parallel operation, circuit breakers are to have a pole for a common-wire mated mechanically with the other poles of the circuit breaker so it would switch on before the other poles are connected to the busbars and switch off after their disconnection.

4.5.3.9 Short-circuit currents are to be calculated on the basis of standards or calculation methods approved by the Register.

4.5.3.10 In calculations of peak short-circuit currents, an equivalent short-circuit current source is to contain all generators including synchronous compensators which may be connected in parallel and all electric motors running simultaneously. Currents from generators and electric motors are to be calculated on the basis of their parameters. When the precise data are lacking, the following ratios of the actual current contribution of the short-circuit point are to be taken for alternating current electric motors:

at the instant of short-circuit occurrence — $6{,}25I_r$;

at the instant T, i.e. after one cycle from short-circuit inception — $2{,}5I_r$;

at the instant 2T, i.e. after two cycles from short-circuit inception — I_r;

for peak current — $8I_r$;

(I_r = total rated current of the electric motors running simultaneously under design conditions).

For the evaluation of the peak value of short-circuit current in direct current systems, the value of electric motor contribution current is taken to be equal to the six-fold sum of the rated currents of electrical motors running simultaneously under design conditions.

The calculation of short-circuit currents is to be made for all design short-circuit points which are necessary for the selection and test of power electric circuit elements. In any case, the calculation of short-circuit currents is to be made for the following design points:

on the generator side — on the circuit breaker terminals;

on collecting busbars of the main switchboard;

on busbars of the emergency switchboard;

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

The calculation of the minimum short-circuit current is to be made if it is required for the assessment of the installation protection sensitivity.

The calculation of short-circuit currents is to include the list of all switching devices fitted, with indication of their characteristics, and also the prospective short-circuit current at the points of their installation.

4.5.4 Layout of switch apparatus and measuring instruments.

4.5.4.1 Apparatus, measuring and indicating instruments associated with relevant generators and other large essential services are to be fitted on the switchboards relating to these generators and services.

This requirement may be missed out for generators if the central control console in which switch apparatus and measuring instruments of several generators are fitted, is available.

4.5.4.2 One ammeter and one voltmeter are to be provided for each direct-current generator on the main and emergency switchboards.

The following instruments are to be provided for each alternating current generator on the main switchboard and for an 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 allowed for generators running in parallel with change-over to each generator);

.4 a wattmeter (for output over 50 kVA);

.5 other instruments as required.

4.5.4.3 Where the circuit breakers with control blocks being capable of outputting separate parameters to a built-in monitor are used on the main or emergency switchboards for the connection and protection of powerful consumer generators or section switchboards, it is allowed not to install the relevant measuring instruments.

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

4.5.4.5 On the main switchboard, each feeder energized from the external source of electrical power is to be provided with:

.1 switchgear and protective devices;

.2 a voltmeter or a pilot lamp;

.3 means of protection against phase breaking.

4.5.4.6 A change-over arrangement or a separate device for measuring insulation resistance is to be installed on the main and emergency switchboards for each isolated distribution system. In any case, the hull leakage current due to the operation of a measuring device is not to exceed 30 mA. Provision is to be made for visual and audible alarms to warn of inadmissable insulation resistance decrease with the output to the main control station over an electric generating system.

4.5.4.7 Measuring instruments are to have scales with a margin of divisions, which exceeds the rated values of quantities to be measured.

The upper scale limits of the instruments are to be not less than:

.1 for voltmeters — 120 per cent of the rated voltage;

.2 for ammeters associated with generators not running in parallel and with current consumers — 130 per cent of the rated current;

.3 for ammeters associated with parallel-running generators — 130 per cent of the rated current for a load-current scale and 15 per cent of the rated current for a reverse-current scale (the last refers to direct current generators only);

.4 for wattmeters associated with generators not running in parallel — 130 per cent of the rated output;

.5 for wattmeters associated with parallel-running generators — 130 per cent for power scale and 15 per cent for reverse power scale;

.6 for frequency indicators — ± 10 per cent of the rated frequency.

The specified scale limits may be changed on agreement with the Register.

4.5.4.8 Voltage, current and power ratings of generators are to be clearly marked on the scales of measuring instruments.

4.5.4.9 Wherever possible, breakers are to be installed and connected to busbars in such a way that none of movable contacts and protective or control devices associated with the breaker is not energized in the position "OFF".

4.5.4.10 Where breakers with fuses are installed in switchboard circuits, the fuses are to be positioned between busbars and breakers. Other pattern of the fuse installation is subject to special consideration by the Register.

4.5.4.11 Where switchboards are installed on a foundation at the floor level, the fuses are to be located not lower than 150 mm and not higher than 1800 mm from the floor level. Live open parts of switchboards are to be located at a height of not less than 150 mm above the floor level.

4.5.4.12 Fuses are to be so installed on switchboards that they are easily accessible and the fuse link replacement is safe for attending personnel. Screwed-in fuses are to be so fitted that feeders could be connected to the central, less accessible, terminal.

4.5.4.13 The fuses protecting the poles or phases of the same circuit are to be installed in a row, horizontally or vertically depending on the fuse design. The fuses in an alternating current circuit are to be positioned to follow the sequence of phases from left to right or from top to bottom.

In direct current circuit, the positive-pole fuse is to be on the left, at top or closer to reach.

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

4.5.4.15 The ammeters of direct current compound generators intended for running in parallel are to be included in the circuit of the pole not connected to the common wire.

4.5.4.16 For connecting movable or semi-movable instruments, flexible stranded conductors are to be used.

4.5.4.17 Apparatus controls, instruments, panels and outgoing circuits on switchboards are to have their designations marked. The apparatus switching positions ("ON", "OFF") are also to be indicated. In addition, markings are to be provided to indicate the rated currents of fuses fitted, and the settings of circuit breakers and electrothermal relays.

4.5.4.18 Each outgoing circuit in a switchboard is to be provided with a breaker to disconnect all poles and/or phases. Breakers may be dispensed with in secondary light distribution boxes provided with a common breaker, and also in the circuits of instruments, interlocking and alarm devices, and of local lighting of switchboards protected with fuses.

4.5.5 Visual alarm.

4.5.5.1 Visual alarm is to be of the colour specified in Table 4.5.5.1.

Table 4.5.5.1

Colour	Meaning	Signal type	Object condition
Red	Emergency	Continuous (bliking)	Emergency disconnection by protective device
Yellow (orange)	Failure	Continuous (bliking)	Abnormal condition (overload, walk-down etc.)
Green	Operation	Continuous	Normal mode
White (blue)	Supply voltage	Continuous	Machinery is ready to start (operate)

The use of light signalling methods other than that specified in 4.5.5.1 (e.g. other colours, letter symbols) is, in each case, subject to special consideration by the Register.

4.5.6 Arrangement of switchgear.

4.5.6.1 Main and section switchboards, and other switchgear are to be installed in locations where possible concentration of gases, petroleum and water vapours, dust and acid evaporations is eliminated.

4.5.6.2 Where the switchgear having protective enclosure of IP10 type and below is located in a special space, cabinet or recess, such spaces are to be made of non-combustible material or to have a lining of such material.

4.5.6.3 Arrangement of pipelines and tanks near the switchboard is to meet the requirements of Part VIII "Systems and Piping" of MODU/FOP Rules.

4.5.6.4 Generator sets and the main switchboard connected to them are to be located in one space or in one main vertical fire zone.

Recesses for the main switchboard, main control station or other special electrical spaces within the main boundaries of machinery space are not considered to separate them from generator sets.

4.5.7 Access to switchboards.

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

4.5.7.2 Behind the free-standing switchboards, it is necessary to provide a passageway of not less than 600 mm wide for switchboards up to 3 m long, and of not less than 800 mm wide for longer switchboards.

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

4.5.7.3 The space behind the free-standing switchboards with open live parts is to be enclosed and provided with doors in accordance with 2.8.1.

4.5.7.4 For switchboards of more than 3 m long, at least two doors are to be provided leading from the space where the switchboard is installed into the space behind the switchboard. Those doors are to be as widely spaced as possible. It is allowed for one of those doors to be opened into the adjacent space having at least another exit.

4.5.7.5 The passageways specified in 4.5.7.1 to 4.5.7.3 are measured from the most protruding parts of apparatus and switchboard structures to the protruding parts of equipment or hull structures.

4.5.7.6 Dielectric mats are to be placed in passageways in front of and behind switchboards.

4.5.7.7 Additional requirements for arrangement of switchgear for voltage over 1000 V are given in Section 18.

5 ELECTRIC DRIVES OF MACHINERY AND ARRANGEMENTS

5.1 GENERAL

5.1.1 The local control stations of drives and the power supply of electrical (electronic) automation systems are to meet the appropriate requirements of Part VII "Machinery Installations" and of Part XIV "Automation" of MODU/FOP Rules, respectively.

5.1.2 Electrically-driven machinery is to be provided with light signals to indicate switching-on of an electric drive.

5.1.3 Equipment provided with automatic, remote and local control is to be so designed that the automatic and remote control is switched off when the change-over to the local one occurs. The local control therewith is to be independent of the automatic or remote one.

5.2 INTERLOCKING OF MACHINERY OPERATION

5.2.1 The machinery provided with electric and manual drives is to be fitted with an interlocking device that prevents possible simultaneous operation of the drives.

5.2.2 If the machinery is required to operate in a certain sequence, appropriate interlocking devices are to be used, the diagram and design of which are subject to special consideration by the Register.

5.2.3 A device may be installed that switches off the interlocking on condition that this device is protected against inadvertent (accidental or unauthorized) use. Information note is to be placed in close proximity to this device indicating its application and forbidding 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 whose electric motors or switchgear require additional ventilation in normal operation is to be possible with ventilation in action only.

5.3 TRIPPING SAFETY DEVICES

5.3.1 Control systems of machinery, whose operation under certain conditions may endanger the safety of people or the unit, are to be provided with tripping devices ensuring the safe trip of electric drive power supply.

The tripping safety devices (buttons, tumblers, etc.) are to be protected against their inadvertent actuation.

5.3.2 Buttons or other tripping safety devices are to be located near control stations or in other places ensuring operation safety.

5.3.3 Electric drives of arrangements and machinery, which require restriction of motion to prevent damage or break-down, are to be provided with limit switches to ensure reliable trip 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 short-circuit protection, is to withstand the short-circuit current that may flow at the point of its installation during the time needed for protection device actuation.

5.4.2 Starting of an electric motor is to be possible only from the zero position of the control gear.

5.4.3 A field killing device is to be provided for the control gear that permits isolation of shunt field windings.

5.4.4 For each electric motor rated at 0,5 kW and over and for its control gear, provision is to be made for fitting a device to isolate the power supply; where the control gear therewith is mounted on the main switchboard or on any other switchboard in the same compartment and its visibility from the place of electric motor installation is ensured, then for this purpose, it is allowed to use the switch mounted on the switchboard.

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

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

.2 an additional switch near the electric motor;

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

5.5 ELECTRIC DRIVES OF PUMPS

5.5.1 The electric motors of fuel oil and lubricating oil transfer pumps and of separators are to be provided with remote disconnecting switches placed outside the spaces wherein these pumps are located and outside machinery casings, but in close vicinity of the exits from those spaces.

5.5.2 The electric motors of the pumps discharging liquids overboard through drain holes above the lightest waterline at locations where lifeboats or liferafts are launched, are to be provided with disconnecting switches placed near the control stations of launching appliance drives for the relevant lifeboats or liferafts.

5.5.3 The electric motors of submersible drain and emergency fire and ballast pumps are to be provided with remote starting devices placed above the bulkhead deck. Those devices are to be provided with a light signal indicating the "ON" condition of the electric drive.

5.5.4 The disconnecting switches of electric drives specified in 5.5.1 are to be located in conspicuous places, protected against an inadvertent action and provided with explanatory notes.

5.5.5 Local starting of fire, ballast and drain pumps is to be possible even in case of failure of their remote control circuits.

5.5.6 The electric motors of fire, ballast and drain pumps (at least one from each pair) are to be supplied through an emergency switchboard and be capable of functioning in case of failure of power supply from the main source of electrical power.

5.5.7 Cables and cable entries of submersible pumps are to be appropriately protected against mechanical damages and are to be functional at the maximum pressure of a water column for the deepest waterline when the MODU hull is damaged.

5.5.8 The electric motors of oily water or sewage transfer of discharge pumps are to be provided with remote cut-off arrangements located in the vicinity of discharge manifolds.

5.6 ELECTRIC DRIVES OF ANCHOR AND MOORING MACHINERY

5.6.1 In addition to the requirements of Part VII "Machinery Installations and Machinery" of MODU/FOP Rules, the drive of windlasses, anchor and mooring capstans, and mooring winches is to meet the requirements of this Part.

5.6.2 When alternating current squirrel-cage electric motors are used, the electric drives of anchor and mooring machinery are to ensure, after 30-minute operation at the rated load, possible stalling of the electric motor in "ON" position at the rated voltage for at least 30 s for the anchor machinery and 15 s for the mooring machinery. For pole-changing motors, this requirement is applicable to operation of motors with the winding producing the maximum starting torque.

The direct current electric motors and alternating current wound-rotor electric motors are to withstand the above stated stalling conditions, but at the torque twice that of the rated value with the voltage which may be below the rated value.

After stalling conditions, the temperature rise is not to be over 130 per cent of the permissible value for the insulation used.

5.6.3 For anchor and mooring capstans and mooring winches, provision is to be made for overload protection of the electric motor at the speed steps intended only for mooring operations.

5.7 ELECTRIC DRIVES OF FANS

5.7.1 The electric motors of fans in machinery spaces and in spaces associated with hazardous zones are to have at least two disconnecting devices with one of them located outside these spaces or their trunks, but in close vicinity of the exits from these spaces.

5.7.2 The electric motors of fans of cargo holds, other industrial spaces, and also of galley fans are to have disconnecting devices placed in locations readily accessible from the deck, but outside machinery space trunks.

The electric motors of an exhaust ventilation for cooking ranges irrespective of the number of disconnecting devices are to be provided with one located immediately in the galley space.

5.7.3 The electric motors of accommodation and service spaces fans are to be provided with at least two remote switching devices with one located in the bridge control station and another accessible from an exposed deck.

5.7.4 The electric motors of fans for spaces covered with a fire-smothering system are to have a disconnecting device automatically actuated when the system is activated for the given space.

5.8 ELECTRIC DRIVES OF BOAT WINCHES

5.8.1 The electric drive of a boat winch is to meet the requirements of Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

5.8.2 The controls of the electric drive for a winch boat are to be provided with self-return to the "Stop" position.

5.8.3 A switch in power circuit of the electric motor is to be fitted near the boat winch control station.

5.9 ELECTRIC DRIVES OF WATERTIGHT AND FIRE DOORS

5.9.1 The electrical drives of watertight doors are to meet the requirements of Part II "Equipment, Arrangements and Outfit" of MODU/FOP Rules.

5.9.2 Power supply of electric drives and indicators of open and closed positions of watertight doors is to be effected from the main, emergency and emergency temporary sources of electrical power in accordance with the requirements of 4.2 and 9.3.

5.9.3 The electrical drives of devices for holding fire doors in the open position (see Part VI "Fire Protection"of MODU/FOP Rules) are:

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

.2 to be remotely controlled from the bridge and reserve control stations of the unit for closing the doors individually, in groups or all at a time;

.3 automatically to close all the doors at a time in case of the supply voltage loss;

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

5.10 ELECTRIC DRIVES OF SELF-PROPELLED MODU STEERING GEAR

5.10.1 The main and auxiliary steering gear needed to steer the MODU, are to be provided with electric or electro-hydraulic drives.

5.10.2 The electric systems of main and auxiliary steering gear are to be so designed that any malfunction in one system could not disable another. The very principle is to be used when two or more similar sets are installed instead of the main and auxiliary drives of the steering gear.

5.10.3 The parameters and power of the electric motor of the steering gear are to be determined with regard to the required break and maximum working torque of the drive for all potential operational conditions. The ratio of a tilting moment to a rated one is to be at least 1:6.

5.10.4 Each electric motor of the main and auxiliary steering gear is to have its own starter located in the unit's steering compartment. The starters may be fitted in switchboard spaces where they are supplied from.

5.10.5 Each electric or electro-hydraulic drive consisting of one or more sets is to be supplied by two feeders from the main switchboard laid in different cable runs spaced as far as possible. One of those feeders is to be supplied from the emergency switchboard. The auxiliary electric or electro-hydraulic drive may be fed from the main drive feeder.

5.10.6 Each feeder is to be designed for supply of all the electric motors and control gear, which are connected to it and may operate simultaneously.

5.10.7 If the main source of electric drive supply fails, provision is to be made for automatic supply restoration within 45 s from an emergency source of electrical power or from other independent source located in a steering compartment and intended only for that purpose.

5.10.8 Each start-stop system of electric drives is to be supplied from the relevant electric motor feeders.

5.10.9 Electric drive control systems of a steering gear are to be supplied by separate feeders laid in different cable runs from the relevant starters in a steering compartment, or from the busbars of switchgear supplying power circuits of the steering gear.

5.10.10 Short-circuit protection only is to be provided for each power and control circuits. No other types of protection are to be provided.

Overcurrent protection may be allowed if it comes into action not less than at the twofold rated current with the relevant time delay. That protection is not to be actuated by starting currents of electric motors.

5.10.11 Starting and stopping of the electric motors of the steering gear are to be effected from the wheelhouse and from the steering room. Provision is to be made in the steering room for devices disconnecting remote starting and stopping, and ensuring switching-in of the motors at any malfunction of remote control. Starting devices are to ensure automatic restarting of the electric motors as soon as the voltage is restored after a discontinuity in power supply.

5.10.12 The control system of the main steering gear is to provide for an opportunity of control both from a wheelhouse and from a steering room. The same is also true for the control system of the auxiliary drive for the steering gear, and both control systems are to be independent of one another.

5.10.13 Where a steering gear with two or more identical electric drives is installed, at least two independent control systems being capable of ensuring control both from a wheelhouse and from a steering room are to be provided. In this case, no handwheel or other controls duplication is needed. If the control system is provided with a hydraulic setting mechanism, its duplication is not required as well.

5.10.14 In the wheelhouse and at the propulsion plant control station in the machinery space, visual and audible alarms are to be given in the event of:

.1 supply voltage loss, phase break-off and each power unit overload;

.2 supply voltage loss in each control system;

.3 low oil level in each hydraulic system tank.

In addition, light indication of steering gear power units operation is to be provided.

5.10.15 A rudder position indicator is to be installed in a wheelhouse. That device is to be independent of steering gear power units and their control systems. The device is to be supplied from an emergency switchboard or from other independent source of electrical power, e.g. from other continuous supply system. Rudder position indication is also to be provided in the wheelhouse, but it may be of the non-electrical type.

5.10.16 Duplicated power circuits and the relevant control systems of steering gear with their components in control cabinets and panels are to be physically separated from each other as far as possible. The relevant cables are to be laid in different cable runs spaced as much as possible, both in the vertical or in the horizontal, along their entire length.

5.11 ELECTRIC DRIVES FOR BURNER UNITS OF BOILERS AND INCINERATORS

5.11.1 Electric drives for burner units of boilers and incinerators are to be provided with remote shut-off devices located outside the spaces, in which they are installed (see also 5.3.8, Part X "Boilers, Heat Exchangers and Pressure Vessels" and 4.3.5, 4.10.3.4 and 6.2.3, Part XIV "Automation" of MODU/FOP Rules.).

5.11.2 Where the spaces in which incinerators and boilers ate installed are protected by aerosol fire extinguishing system, the electric drives for burner units of boilers and incinerators are to be automatically shut down when the above system is activated.

6 LIGHTING

6.1 GENERAL

6.1.1 All spaces, locations and areas of the unit where the illumination is essential for personnel safety, machinery and appliances control, people habitability and evacuation are to be provided with stationary main lighting fixtures supplied from the main source of electrical power.

6.1.2 The spaces, locations and areas where the emergency lighting fixtures are to be installed in addition to the main ones are listed in 9.3.1.1.

Lighting fixtures installed in spaces and areas with potential mechanical damage to their globes are to be provided with guard meshes.

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

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

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

6.1.6 Battery and other hazardous spaces and areas are to be illuminated with lighting fixtures, located in adjacent safe spaces, through gastight glazed windows or with safe-type lighting fixtures located inside the spaces.

6.2 POWER SUPPLY OF MAIN LIGHTING

6.2.1 The switchboards of the main lighting are to 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 electric heaters rated up to 10 A in cabins.

6.2.2 The protective devices of final tapped-off lighting circuits are to be designed for a rated current of not more than 16 A, the total load current of the consumers connected is not to exceed 80 per cent of the rated current of the protective device.

The number of lighting fixtures supplied from the final lighting circuits is not to exceed that specified in Table 6.2.2.

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 exposed decks, machinery spaces, control station spaces, galleys of service and public spaces, corridors, stairways, tunnels, exits to an exposed deck etc. is to be supplied by not less than two independent feeders with the lighting fixtures arranged in such a manner that in case of failure of either feeder the above spaces and areas are not fully deprived of lighting, which is to be as uniform as possible. These feeders are to be supplied from different group boards, which, in their turn, are to be supplied from different sections of power distribution system busbars.

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

6.2.5 Lighting of spaces and areas of MODU or FOP each fire zone is to be supplied by two feeders independent of the feeders supplying lighting of other fire zones.

The lighting feeders, as far as practicable, are to be laid in such a manner that a fire in one zone cannot damage the lighting feeders in other zones.

Where the sectionalized lighting busbars in the main switchboard are used, such feeders are to be supplied from different busbar sections.

6.2.6 The main lighting circuits are to be so designed that if they fail in fire or other emergency in the spaces accommodating the main sources of electrical power and/or main lighting transformers, the emergency lighting system in these spaces will not become disabled.

6.3 EMERGENCY LIGHTING

6.3.1 The illumination in the separate spaces, locations and areas specified in 9.3.1.1 under emergency lighting is to be not less than 10 per cent of the general illumination under main lighting (see 6.7). It is allowed that the illumination from emergency lighting fixtures in a machinery space accounted for 5 per cent of the main lighting illumination if the socket outlets fed from the emergency lighting circuit and intended for portable lighting fixtures are provided.

6.3.2 In order to obtain the illumination specified in 6.3.1, the emergency lighting fixtures with incandescent lamps may be combined with luminescent lamps.

6.3.3 Main lighting fixtures may be used as emergency ones if they may also be fed from emergency sources of electrical power.

6.3.4 The emergency lighting circuit is to be so designed that if it fails in fire or other emergencies in the spaces accommodating the emergency sources of electrical power and/or emergency lighting transformers, the main lighting system will not become disabled.

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

6.3.6 Every emergency lighting fixture and combined lighting fixture, i.e. jointly with the emergency one, is to be marked red.

6.3.7 Low-location emergency lighting (electrically-powered).

6.3.7.1 The low-location lighting system is to be supplied from emergency switchboard busbars in such a manner that it is capable of functioning both under normal conditions, while main generators are operational, and under emergency conditions. The system is to be in continuous operation.

6.3.7.2 Low-location lighting is to ensure the following levels of luminosity:

.1 active system parts are to have the minimum luminosity of 10 cd/m^2;

.2 the point sources of miniature incandescent lamps are to provide not less than 150 mcd mean spherical intensity with a spacing of not more than 100 mm between lamps;

.3 the point sources of light-emitting diode systems are to have a minimum peak intensity of 35 mcd. The angle of half intensity spherical cone is to be appropriate to the likely track directions of approach and viewing. Spacing between the light-emitting diodes is to be not more than 300 mm.

6.3.7.3 The supply of a low-location lighting system is to be arranged so that the failure of any light source and the fire in one fire zone or on one deck will not result in the failure of lighting and escape route signs in another fire zone or on the deck.

6.3.7.4 The failure of or damage to any light source is not to result in the loss of visible outline of the escape route at the length over 1 m.

6.3.7.5 The type of light source enclosure protection is to be at least IP55.

6.4 SWITCHES IN LIGHTING CIRCUITS

6.4.1 Two-pole switches are to 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 of lighting fixtures rated for safety voltage.

6.4.2 For permanently installed external-illumination lighting fixtures, provision is to be made for centralized switching off all the lighting fixtures from the unit's bridge control station or from other manned station on the upper deck.

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

6.4.4 The switches of lighting behind free-standing switchboards are to be fitted at each entrance behind the switchboard.

6.4.5 In emergency lighting circuits, local switches are not to be used. It is allowed to use local switches in the circuits of emergency lighting fixtures which, under normal conditions, serve as the main lighting fixtures.

The unit's bridge control station is to be provided with the switch of an emergency lighting system.

Emergency lighting fixtures of embarkation stations which, under normal conditions, serve as the main lighting fixtures are to switch on automatically when the main switchboard busbars are de-energized.

6.5 INCANDESCENT AND GAS-DISCHARGE LIGHTING FIXTURES

6.5.1 Lighting fixtures are to have such a design that cable entries are of a sufficient length and free from rough ledges, sharp angles and sudden bends. All exits for cables are to have well-rounded edges and to be appropriately worked to prevent damage to a cable.

6.5.2 Insulated conductors are to be provided with an opportunity of being so connected to terminals that they could not contact other current-carrying elements inside a lighting fixture under vibration conditions.

6.5.3 Lighting fixtures are to be so designed that dust and moisture could not accumulate in their interior on current-carrying parts and insulation.

6.5.4 Current-carrying parts of lighting fixtures are to be reliably isolated from a housing or an enclosure.

6.5.5 All metal parts of lighting fixtures are to be electrically connected between themselves and the specially provided earthing terminal.

6.5.6 The components supporting current-carrying parts in tube retainers are, as a minimum, to be made of materials not maintaining burning and of non-combustible materials for luminescent and incandescent lamps, respectively.

6.5.7 The type of lighting fixture enclosure (case) is to be IP 2X, as a minimum.

6.5.8 In lighting fixtures for spaces such as bathrooms, laundries, galleys and the like, the components of tube retainers which may be touched by personnel during lamp replacement are to be made of or covered with insulating material and provided with a protection shield.

6.5.9 Where lighting fixtures are supplied from a system with an earthed neutral, the external tube retainer contact is to be connected to a neutral conductor of a supply system.

6.5.10 Chokes and capacitors of luminescent lighting fixtures are to be protected securely with metal enclosures.

6.5.11 Capacitors of 0,5 μF and over are to be fitted with discharging devices. The discharging device is to be so designed that the voltage of the capacitor does not exceed 50 V in 1 min after disconnection from supply.

6.5.12 Chokes and transformers having a high inductive reactance are to be installed as close as possible to the lighting fixture they serve. The transformers are to have their primary and secondary windings electrically-separated and not to include combustible materials and liquids.

6.5.13 Gas-discharge lighting fixtures supplied at over 250 V are to be provided with caution notes giving the voltage rating. All live parts of such lighting fixtures are to be protected against an inadvertent touch during maintenance.

6.5.14 The lighting fixture design is to provide the relevant removal of heat from cases which is caused by the heating from lamps, ballast resistors, capacitors, etc. The temperature of lighting fixture surfaces which may be touched in maintenance is not to exceed 60 °C.

6.5.15 The excess of temperature for terminals used for the connection of supply cables over the ambient temperature is not to exceed 40 °C.

6.5.16 The insulation class of wires used for internal connections is to be consistent with the maximum temperature inside lighting fixture cases.

6.5.17 Tube retainers (lampholders) used in lighting fixtures are to be of the standard type in accordance with Table 6.5.17.

Table 6.5.17

Tube retainer type	Permissible lamp characteristics	
	Voltage, V	Output, W/ Current, A
With screwed lamp-base:		
E40	250	3000/16
E27	250	200/4
E14	250	15/2
E10	24	
With bayonet lamp-base:		
B22	250	200/4
B15d	250	15/2
5s	55	15/2
For bar luminescent lamps:		
G13	250	80/
G5	250	13/
For linear halogen and metal-haloid lamps:		
R7s	250	1500/
Fa4	250	2000/

6.5.18 Tube retainers for lamps with the E40 lamp-base are to be fitted with devices to locate (secure) the lamp in a holder.

6.6 SOCKET OUTLETS

6.6.1 Socket outlets for portable lighting fixtures are to be installed at least:

.1 on deck near windlass and mooring winch control stations;

.2 in spaces for a gyrocompass and other navigational equipment (if any);

.3 in the radio equipment converter room;

.4 in the steering gear and thruster compartments (if any);

.5 in the emergency generator set compartments;

.6 in the machinery spaces;

.7 behind the main switchboard;

.8 in special electrical spaces;

.9 at bridge and reserve control stations;

.10 in the radioroom (if any);

.11 in the vicinity of recesses for a log, echo-sounder, other devices associated with measurements of environmental parameters;

.12 in spaces where centralized ventilation and air-conditioning installations are located.

6.6.2 Socket outlets for portable equipment which are fed with different voltages are to be so designed as to prevent the insertion of a plug intended for one voltage into a socket for another one.

6.6.3 Socket outlets for portable lighting located on exposed decks are to be mounted with their face looking downward.

6.6.4 Socket outlets are not to be fitted in machinery spaces below plating, in enclosed fuel and oil separator rooms or in locations where explosion-proof type equipment is required.

6.7 ILLUMINATION

6.7.1 The illumination of particular spaces and areas is to be not less than that required by national sanitary standards and at least not less than specified in Table 6.7.

The general lighting standards given in Table 6.7 refer to the level of 800 mm above the deck (floor) of a space, while the standards of the general plus local lighting, to the level of working surfaces.

The general lighting is to be measured at the level of 1 m above the deck (floor), and the local lighting — directly above the working surface.

6.8 SEARCHLIGHTS AND ARC LAMPS

6.8.1 All parts of searchlights or arc lamps to be maintained and adjusted in operation are to be so designed as to prevent the electric shock risk for an operator.

6.8.2 Switches intended for searchlights or arc lamps are to be multipolar.

6.8.3 Where series resistors are used with arc lamps, switches are to disconnect both the lamp and its series resistor from the network.

Table 6.7

Spaces and areas	General (average) illumination (E_{av}), lux	Minimum illumination, lux	Maximum illumination, lux
Exterior spaces (main lighting)	50	20	100
Interior rooms, corridors, accommodation spaces (main lighting)	100	40	200
Stairways	150	60	300
Process spaces attended periodically	150	60	300
Process spaces attended frequently	300	150	450
Drilling site	300	150	450
Control stations, laboratories	500	250	750
Machinery rooms, pump rooms	200	80	400
Auxiliary machinery rooms	200	80	400
Workshops	300	120	600
Switchboard rooms	300	150	450
Service rooms (offices)	500	250	750
Laundries, galleys, mess rooms	300	120	600
Sick-bay, hospital	300	120	360
Local lighting in sick-bay	1000	500	1500
Rooms for radio equipment	500	250	750
Emergency sick-bay (if provided)	300	120	360

Notes: 1. Number of gauge points required for illumination gauging is chosen from the below table and depends on the space index calculated by the formula:

$K = (ав)/h(a+b)$,

where K is the index;

a and c are the lateral lengths of a space;

h is level of a lighting fixture above working area.

Space index K	Number of gauge points
Less than 1	4
From 1 up to 2	9
From 2 up to 3	16
3 and more	25

2. Design of initial illumination levels is to provide for natural deterioration of illumination due to lamps aging and lighting fixtures clogging.

7 INTERNAL COMMUNICATION AND ALARMS

7.1 ELECTRIC ENGINE TELEGRAPHS OF SELF-PROPELLED MODU

7.1.1 In addition to the requirements of this Chapter, engine telegraphs are to meet the requirements of Part VII "Machinery Installations and Machinery" of MODU/FOP Rules.

7.1.2 Engine telegraphs are to have an illumination-adjusted dial, to be provided with visual indication of voltage presence and audible warning of voltage loss in the power circuit.

7.1.3 Engine telegraphs are to be fed from the main switchboard or from the navigation equipment switchboard.

Where the MODU is provided with an integrated bridge control console, the engine telegraph may be fed from this control console.

7.1.4 The engine telegragh is to be so installed at the bridge control station that when an order to move the unit is executed, the telegraph handle shifts in the same direction as the unit. The vertical position of the handle is to correspond to the "Stop" order.

7.1.5 Where engine telegraphs and devices for remote control of the main engines and controllable pitch propellers are located on sloping desks of control panels, the handle in the "Stop" position is to be perpendicular to the panel surface and be precisely fixed in that position.

7.1.6 Where two or more engine telegraphs are located in the close proximity to one another (on one deck), they are to ensure the transmission of orders from any one of them and the reception of response by all of them simultaneously, without additional changing-over.

Change-over to the telegraphs located on another deck or in another part of the unit is to be effected by means of switches fitted on the navigating bridge (at the bridge control station).

7.1.7 Each engine telegraph is to be provided with an audible signal arrangement that ensures the actuation of an audible alarm by the transmitting and receiving device when an order is given and responded. The audible signal arrangement is to continue functioning until the right response to the given order is received (see also Part VII "Machinery Installations and Machinery") of MODU/FOP Rules.

7.2 INTERNAL SERVICE COMMUNICATION

7.2.1 Provision is to be made for independent two-way telephone communication between the bridge, reserve and local control stations of the machinery installation, and also between the bridge control station and the radioroom (if it is outside the bridge control station).

If the MODU or FOP main control station of the machinery installation is of the enclosed or outdoor type, independent two-way voice communication between the main machinery control room and bridge and reserve control stations is also to be provided.

For this purpose, use may be made of either independent two-way telephone communication or two-way telephone communication between the bridge and main machinery control room with telephones connected in parallel and installed at the local control stations.

7.2.2 In addition to the communication facilities specified in 7.2.1, provision is to be made for a separate system of independent telephone communication between the bridge and reserve control stations and:

the stations in the main service spaces;

the stations on the forecastle and poop;

the watch station on the mast (if any);

the stations in the steering gear compartment,

the spaces for thrusters, an emergency switchboard, essential navigation equipment, a fire smothering station;

engineers' accommodations;

other spaces in which arrangements ensuring MODU or FOP operation safety are located.

Provision is to be made for telephone communication between the main control station, the local control station of the main machinery and engineers' accommodations. For this purpose, a two-way loudspeaker device may be used instead of telephones.

When independent two-way voice communication between the bridge and reserve control stations and the above spaces is provided, additional communication facilities need not be installed.

7.2.3 Internal service communication systems are to ensure the possibility to call a subscriber and good audibility under conditions of a specific noise near communication facilities locations. When the service telephone sets are installed in the space of high noise intensity, measures are to be taken for noise absorption or additional handsets are to be provided.

7.2.4 For communication facilities specified in 7.2.1 and 7.2.2 use is to be made of voice-powered telephones or provision is to 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, i.e. from an uninterruptible power supply system.

7.2.5 The damage to or disconnection of one telephone set is not to upset functioning of other sets.

7.2.6 The telephone sets mentioned in 7.2.1 for two-way voice communication are to be fitted with audible and visual alarms to indicate the call both at the main machinery control room and in the engine room.

7.2.7 The two-way loudspeaker device may be independent or combined with the command broadcast apparatus.

7.3 GENERAL ALARM SYSTEM

7.3.1 MODU/FOP are to be provided with a general alarm system which ensures good audibility of alarms in all the spaces and locations where people may be present. A visual alarm, e.g. a rotating flashing lamp is to be fitted in the spaces of the high noise level in addition to an audible alarm.

7.3.2 Sound and visual devices of the general alarm system are to be installecd in the following places:

.1 in machinery spaces;

.2 in service and public spaces;

.3 in corridors of accommodation, service and public spaces;

.4 on exposed decks;

.5 in working spaces and areas.

7.3.3 The general alarm system is to be supplied from the unit's mains, and also from busbars of the emergency switchboard according to the requirements of 9.3.1.7 and 9.3.6.3, or from uninterruptible power supply system of essential equipment.

The general alarm system may be supplied from the mains and from a separate accumulator battery if provision is made for an automatic changeover of general alarm circuits to this battery. In this case, no supply from the emergency and temporary sources of electrical power is needed.

7.3.4 The general alarm system is continuously to be supplied whether the accumulator battery is being charged or discharged.

7.3.5 Where a separate accumulator battery is used for supply of the general alarm system, it may also feed other internal communication and signaling 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.

7.3.6 In circuits supplying the general alarm system, the protection against a short circuit only is to be provided. Protective devices are to be fitted in both conductors of the feeder, and also in circuits of each sound device.

Protection of several sound devices with 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.

7.3.7 General alarm sound devices are to be so located that a signal is clearly heard against the noise in the given space. The sound devices installed in spaces with the high intensity of noise are additionally to be fitted with a visual alarm.

The tonality of general alarm devices is to be distinct from that of devices of other alarm kinds.

Audible alarms (excepting bells) are to have a signal frequency within 200 to 2500 Hz. Means may be provided for regulating the audible signals frequency within the above limits.

7.3.8 The general alarm system is to be actuated by means of a double-pole self-restoring switch from the bridge control station, reserve control station, and also from the space intended for watchkeeping in the absence of personnel at the bridge control station.

A pilot lamp to indicate actuation of the general alarm is to be fitted in the switch circuit at control stations.

The switches are to be provided with inscriptions indicating their purpose.

7.3.9 No switching devices are to be incorporated into the circuits of the general alarm system other than the switch specified in 7.3.8. In order to prevent unauthorized disconnection of the general alarm system, its switchboard is to be fitted with the interlocking device of a power supply switch in the "ON" position or with other devices preventing access to it for unauthorized persons.

It is permitted to use intermediate contactors controlled by the switch, but not more than one contactor in each section.

7.3.10 Sound devices, switches and switchgear of the general alarm system are to be provided with readily visible distinctive symbols.

7.3.11 The network of general alarm sound devices is to consist of at least two sections controlled with one switch, and the sound devices are to be so positioned that in spaces of large area (machinery spaces, boiler rooms, process spaces and others) they are connected to different sections.

7.4 FIRE DETECTION SYSTEM

7.4.1 In addition to the requirements of this Chapter, fire detection systems are to meet the requirements of Section 4, Part VI "Fire Protection" of MODU/FOP Rules.

7.4.2 Application of fire detectors located in spaces of potential explosive vapours accumulation or being in the air flow from these spaces is regulated by 2.9.

7.4.3 For power supply of a fire detection system, provision is to be made for at least two sources of electrical power one of which is to be an emergency one. The power supply is to be effected by separate feeders intended for that purpose only. If the main source of electrical power fails, provision is to be made for an automatic changeover of supply to the emergency source with actuation of an audible and visual alarm. Where an accumulator battery is the main source of power supply, two separate accumulator batteries (main and standby) are to be provided, with the capacity of either being sufficient for operation of the fire detection system for at least 3 days without recharge.

7.4.4 The fire detection system operating on the principle of sampling the air from protected spaces to convey it to an indicating unit is to be fed along with its fans by separate feeders from the main and emergency sources of power or from another independent source of electrical power.

7.4.5 The central indicating unit of a fire detection system is to be designed in such a manner that:

.1 any signal or damage to one circuit does not effect normal functioning of other circuits;

.2 a fire detection signal dominates over other signals coming to the indicating unit and allows to determine the location of the space wherefrom this signal has come;

.3 contact-type fire detector circuits operate for opening; it is permitted to use detectors operating for closing if their contacts are sealed and their circuit is monitored for an open-circuit and ironwork fault;

.4 provision is made for monitoring its operation;

.5 provision is made for the disconnection of separate sections or detectors. In this case, a visual alarm is to be provided to indicate that the section or detector is turned off.

7.4.6 The indicating unit of a fire detection system is to produce, as a minimum, the information specified in Table 7.4.6.

A visual signal of fire detection is to be designed in such a manner that it consists of two indicators (two lamps or a double filament), or a special device is to be provided to check the proper condition of signaling lamps. The colour of the visual signal is to comply with the requirements of 4.5.5.

Table 7.4.6

Nos	Operation mode	System with temperature detector	System with air sampling
1	In operation	Light	Light
2	Power supply from emergency source	Light & Sound	Light & Sound
3	Fire	Sound, light and location	Sound, light and location
4	Detector malfuncion	Light & Sound	—
5	Sampling fan malfunction	—	Light & Sound

Visual signals are to be individual for each kind of information.

The signals intended for determination of the location of the space or area, wherefrom a pulse has come, may be common with the signal of fire detection or damage.

Visual signals are to function from the moment a pulse is received till the moment the cause of their actuation has been eliminated with the signal specified in item 1 of Table 7.4.6 continuously operating irrespective of the power supply source type.

7.4.7 If the fire detection alarm has not received (acknowledged) in the indicating unit within two minutes, fire alarm is automatically to be actuated in machinery, accommodation and other spaces where personnel may be present.

7.4.8 Fire detection systems with a zone address identification capability are to be so designed that:

.1 a loop cannot be damaged at more than one point by fire;

.2 means are provided to ensure that any damage (e.g. power break, short circuit, earthing) to the loop will not disable its remaining part;

.3 an opportunity is provided to quickly restore the operation of the system if its mechanical, electric and electronic elements fail;

.4 the actuation of the first fire alarm does not prevent that of any other detector and giving subsequent alarms.

7.4.9 Two indicating units, as a minimum, are to be provided in a fire alarm system. The central indicating unit is to be located at the main control station and the back-up one at the reserve control station.

7.4.10 Fire alarm detectors and manual fire alarms are to be fitted in the spaces and locations in which a fire may occur. Provision is to be made for detectors and/or manual fire alarms in all the spaces for industrial machinery and components, in machinery spaces, control stations, switchboard spaces, corridors, cabins, store rooms and other spaces of an accommodation module. Manual fire alarms are to be fitted in places where personnel is usually present. The drawings of detectors and manual fire alarms layout are subject to the Register consideration.

7.4.11 If the automatic stop of industrial or other essential equipment is made, when fire alarm is actuated, then, in this case, the system design is to ensure the improved reliability of alarm actuation through redundancy and the logical processing of detector signals. The above requirement may be effected, for instance, by fitting in one space at least three detectors connected to different sections (circuits) using majority voting two in every three.

7.4.12 When a fire alarm is actuated, the central station is to put out to external devices, as a minimum, the following control signals:

into the system of the emergency stop of industrial process machinery and arrangements for the activation of one of the levels depending on the ignition address;

into the system of the emergency stop of the fans of appropriate spaces, and for closing of fire doors and dampers;

into devices for the emergency start of fire pumps;

into the MODU general alarm system.

7.5 WARNING ALARM OF SMOTHERING SYSTEM RELEASE

7.5.1 In addition to the requirements of this Section, the warning alarm system is to meet the requirements of Part VI "Fire Protection" of MODU/FOP Rules.

7.5.2 The warning alarm system is to be fed from the unit's mains and an accumulator battery having a capacity sufficient for system operation during 30 min.

Provision is to be made therewith for a device to automatically change over power supply of the warning alarm system to the accumulator battery in case of the unit's mains voltage loss.

7.6 INDICATION OF WATERTIGHT AND FIRE DOORS CLOSURE

7.6.1 The visual alarm (indication) to show whether the watertight doors and companion hatches are open or closed as required by 8.3.3 and 8.4, Part III "Equipment, Arrangements and Outfit of MODU/FOP" of MODU/FOP Rules is to be power supplied from the unit mains and an independent power source as specified in 7.3.3.

7.6.2 The visual alarm (indication) to show whether the fireproof doors are open or closed as required by 2.1.5, Part VI "Fire Protection" of MODU/FOP Rules is to be power supplied from the unit mains and an independent power source as specified in 7.3.3.

7.7 MACHINERY INSTALLATION ALARM SYSTEM IN ENGINEERS' ACCOMMODATIONS

7.7.1 Provison is to be made for the generalized alarm system of a machinery installation in engineers' accommodations in accordance with the requirements of Part XIV "Automation" of MODU/FOP Rules.

7.7.2 In addition, provision is to be made in the same accommodations for an audible and visual alarm of the engineer's call in emergency, manually-activated at the main machinery control room of a machinery installation or from a machinery space.

7.7.3 Power supply of the above alarm systems is to be carried out from an uninterruptible power supply source as specified in 4.2.

7.8 NAVIGATION LIGHTS

7.8.1 A special switchboard is to be provided to supply permanently mounted navigation lights listed in Section 2, Part I "Signal Means" of the Rules for the Equipment of MODU and FOP.

7.8.2 The navigation lights switchboard is to be supplied by two feeders:

.1 one feeder from the main switchboard through the emergency switchboard;

.2 the second feeder from the nearest group switchboard which is not supplied from the emergency switchboard;

.3 from an uninterruptible power supply system as specified in 4.2.

7.8.3 Navigation lights are to be connected to a supply circuit with a flexible cable with a plug connector.

7.8.4 The supply circuits of navigation lights are to be of a two-conductor system with a double-pole switch for each circuit to be fitted in the navigation lights switchboard.

7.8.5 Each navigation lights supply circuit is to be provided with protection in both conductors and with visual indication of navigation light functioning.

The visual indicator of the intact condition of a signal lamp is to be designed and installed so that its damage may not result in the navigation light turn-off.

The voltage drop at the switchboard supplying navigation lights including the indicating system of lights functioning, is not to exceed 5 per cent at the rated voltage up to 30 V and 3 per cent at the rated voltage over 30 V.

7.8.6 Irrespective of the indication mentioned in 7.8.5, an audible alarm is to be provided automatically activated when any navigation light fails with the switch in the "ON" position.

The alarm is to be supplied from a source or feeder other than that used for power supply of a navigation lights switchboard, or from an accumulator battery.

7.8.7 The design of navigation lights is to comply with the requirements set out in Section 3, Part I "Signal Means" of the Rules for the Equipment of MODU and FOP.

7.9 EXPLOSIVE GAS DETECTION AND ALARM SYSTEM

7.9.1 A fixed explosive gas detection and alarm system is to be provided at the unit's bridge or main control station to monitor every area and all enclosed spaces of the unit in which a dangerous accumulation of explosive gas mixture may be expected to occur. The back-up panel of the fixed explosive gas detection and alarm system is to be fitted at the unit's reserve (emergency) control station. The system is to be capable of indicating on call the value of explosive gas mixture concentration.

7.9.2 Sensors (gas analysers) of explosive gases concentration are to be installed in at least the following spaces and areas:

in hazardous spaces and areas of zone 1;

in all the inlets of ventilating ducts directing air into non-hazardous zones;

in the spaces and areas specified in Part VI "Fire Protection" of MODU/FOP Rules.

Provision is to be made for an opportunity to disconnect any individual gas analyzer or section from the main control station. In doing so, a visual alrm indicating the disconnected gas analyzer or section is to be activated at the central station.

7.9.3 The alarm system is to give a visual and audible alarm at the bridge control station when the following levels of explosive gas concentrations are detected in the protected spaces:

maximum concentration of 25 per cent of the lower flammable limit for hydrocarbons;

10 ppm and 20 ppm for hydrogen sulphide.

7.9.4 The automatic system for the shutdown of non-explosive type electrical equipment is to be activated when:

explosive gases concentration specified in 7.9.3 reaches 60 per cent of the lower flammable limit;

explosive gases concentration is detected in inlets of the air ducts directing air into non-hazardous zones.

7.9.5 Power supply of an explosive gas detection and alarm system is to be effected from the main and emergency sources of electrical power, or from the uninterrupted power supply system as specified in 4.2.

7.9.6 A gas alarm system is to be capable of self-test. At least on damages like the power supply loss, a power break or a short circuit in sensors, or on damages to a sample lines and ventilation system, an alarm is to be given.

7.9.7 Provision is to be made for the possible check of proper gas alanysers functioning, for instance, by use of calibration aerosols having the fixed gas concentration.

7.9.8 When a gas alarm system is actuated, the signal "GAS" is to be put out to the unit's general alarm system.

7.10 LIGHTING AND ILLUMINATION SIGNAL MEANS FOR HELIDECKS

7.10.1 General.

7.10.1.1 Lighting and illumination signal means for helidecks are to be in compliance with the applicable requirements of Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships.

7.10.1.2 The lighting and illumination signal means for helidecks are to at least provide for the following:

indication of the perimeter (boundaries) of helidecks;

illumination of the landing site;

indication of the elevated structures within the landing site.

7.10.1.3 Lights used for this purpose are to have protection degree not lower than IP56 and function reliably under environmental effects specified in Section 2, Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships.

7.10.1.4 All lighting and illumination signal means, as well as other electrical equipment within the helideck filling stations and hangars are to be of explosion-proof design and have explosion protection degree corresponding to at least temperature class T3 and sub-group IIA.

7.10.1.5 With regard to lighting characteristics, the lights are to comply with the requirements of ICAO (International Civil Aviation Organization), which is to be confirmed by the appropriate conclusion or by the Certificate issued by the Civil Aviation competent body.

7.10.1.6 The lighting and illuminating signal means specified in this Section are to be supplied by a separate switchboard fed from the main and emergency power sources with an automatic change-over in the event of loss of power.

7.10.2 Perimeter lighting.

7.10.2.1 All-round lights each of not less than 40W chained up along the boundary of the landing site are to be provided to indicate the perimeter (boundaries) thereof (at least 8 lights).

7.10.2.2 The distance between adjacent lights is not to exceed 3 m. The lights to indicate the perimeter are to be yellow. Use of yellow and blue lights with sequential alternation thereof may be permitted.

7.10.2.3 The lights are to 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.

7.10.2.4 After installation, the globes of the lights are not to rise to a height of more than 150 mm above the helideck level.

7.10.3 Illumination of the landing site.

7.10.3.1 The landing site and wind direction indicator are to be properly illuminated. For this purpose floodlights may be used.

7.10.3.2 Appropriate measures are to be taken when the illumination signal means are being installed to prevent glare to pilots during take-off, landing and manoeuvring.

7.10.4 Obstruction and warning lights.

7.10.4.1 To provide safety of flight, all considerably elevated structures and items such as superstructure components, drill stem and production strings, etc. are to be marked by special obstruction and warning red lights.

7.10.4.2 Structures and items rising to a height of 15 m and more above the helideck level are to be marked by obstruction lights throughout their full height at 10 m intervals beginning from the uppermost point of the structure.

7.10.4.3 All-round lights of at least 40 W are to be used as obstruction and warning lights.

7.10.4.4 Lights are to be divided into two independent circuits and supplied in such a manner that when power supply to any one circuit fails, the basic part of the obstruction and warning lights remains functioning.

8 ELECTRIC PROTECTION SYSTEM

8.1 GENERAL

8.1.1 Every separate electrical circuit is to be protected against a short circuit and an overload unless another way of protection or an alarm system is specified for the separate circuits (as for instance, for steering gear and fire pump electrical circuits).

8.1.2 Outgoing circuits of switchboards are to be protected against short circuits and overloads by means of devices installed at the inception of each circuit.

No overload protection for the switchboard supply circuit is needed if the current consumers supplied from this switchboard have individual protective devices against overloads, and the cable of the switchboard supply circuit is selected on the basis of the maximum total current for all consumers of this switchboard.

8.1.3 Protective devices are to be so adapted to the characteristics of the equipment under protection that they activate under inadmissible overloads. The rated settings of overload protective devices for each circuit under protection are to be clearly shown on protection instruments.

8.1.4 The protection system is to be selective as to overload currents and to short-circuit currents to be expected. The protection therewith is to be designed so that damages to non-essential consumers and their supply circuits could not adversely affect the reliable functioning of the MODU or FOP generating plant and the power supply of essential services.

Short-circuit and overload protective devices are not to actuate at starting currents of the electrical equipment under protection.

8.1.5 Overload protection is to be provided in:

.1 not less than one phase for a one-phase alternating current system or in a positive pole for a two-conductor direct current system;

.2 not less than two phases for an insulated three-wire three-phase current system;

.3 all phases for a three-phase four-wire system.

8.1.6 Short-circuit protection is to be fitted in each insulated pole of a direct current system, and also in each phase of an afternating current system.

Current settings of short-circuit protective devices are to correspond to at least 200 per cent of the rated current of the protected equipment. The protection may be actuated without or with a time delay needed to attain the relevant selectivity.

8.1.7 Where cables of reduced cross-sectional area are used in some lengths of a supply circuit, additional protection is to be provided for each of such cables unless the preceding protective device is capable of protecting the cable of reduced cross-sectional area.

8.1.8 Protective devices, which exclude the possibility of immediate repeated switching-in after the actuation of protection, are not to be used in the emergency switchboard supply circuits as well as in emergency consumers supply sircuits.

8.1.9 Additional requirements for protective devices in networks with a voltage in excess of 1000 V are given in Section 18.

8.2 GENERATORS PROTECTION

8.2.1 Generators not intended for operation in parallel are to be provided with overload and short-circuit protective devices. Generators intended for parallel operation are to be provided with at least the following protective devices against:

.1 overloads;

.2 short circuits;

.3 reverse current or reverse power;

.4 minimal voltage.

8.2.2 The generators overload protection system is to comply with their overload characteristics and to meet the following requirements:

.1 only a visual and audible alarm system operating with a time delay within the range of 0 to 15 min is to be provided for overloads of up to 10 per cent. The time delay over 15 min is permitted if it is required due to operational conditions and provided by the generator design;

.2 an circuit breaker is to disconnect a generator with the time delay corresponding to 2 min at the 50 per cent overload (i.e. at lesser overloads, the time delay over 2 min is to be provided) for overloads within the range of 10 to 50 per cent. The overload over 50 per cent of the rated one and the 2 min time delay may be exceeded if it is required under operational condition of a generating plant and provided by the generator design;

.3 for overloads over 50 per cent of the rated one, the disconnection of a generator is to occur with the time delay ensuring the proper selectivity for which purpose provision is to be made for the relevant time delays in circuit breakers of generators.

8.2.3 Provision is to be made for devices which automatically and selectively desconnect non-essential consumers at the generators overload. The consumers disconnection may be performed in one or more steps according to the generator overload capability.

8.2.4 Protection of generators intended for operation in parallel against a reverse current or reverse power is to be selected to suit prime mover characteristics. The setting limits for the mentioned protection types are to comply with those given in Table 8.2.4.

Table 8.2.4

Current types	Limits of reverse-current or reverse-power protection settings related to generator prime mover	
	Turbine	Internal combustion engine
Alternating	2 - 6 per cent of rated output, kW	8 - 15 per cent of rated output, kW
Direct	2 -15 per cent of rated current, A	2 - 15 per cent of rated current, A

Reverse-current protection for direct-current generators is to be installed in the pole opposite to that in which an equalizing conductor is connected. Reverse-power or reverse-current protection is still to be capable of operation when the voltage applied is reduced by 50 per cent although the values of reverse current or reverse power may be changed.

8.2.5 Minimal voltage protection is to ensure the possibility of a reliable connection of generators to busbars at a voltage of 85 per cent and over the rated one and to exclude the possibility of the generator-to-busbars connection at a voltage less than 35 per cent of the rated one, and also to disconnect the generators in case of reduction of voltage across its terminals in the range of 70 to 35 per cent of the rated value.

Minimal voltage protection is to operate with a time delay for the disconnection of generators from busbars in case of voltage reduction and to instantaneously actuate at the attempt to make connection to the generator busbars before the minimal voltage specified above is reached.

8.2.6 For generators with the rating of 1000 kVA and over, provision is to be made for protection against internal faults and for the protection of the cable run between a generator and its circuit-breaker on the main switchboard. If a short circuit occurs inside the generator or in the cable run between the generator and circuit breaker, the above protection is to ensure generator de-excitation and the disconnection of its circuit breaker.

8.2.7 Where a turbine-driven direct-current generator is intended for operation in parallel, provision is to be made for a device disconnecting the circuit breaker of the generator when a turbine safety regulator is actuated.

8.2.8 The current settings of protective devices with a time delay are to be selected in such a way that in any case the reliable interruption of a short-circuit current is ensured after the set time delay.

8.2.9 Safety fuses as a protective device for semiconductor elements may be used in generator excitation systems.

8.3 PROTECTION OF ELECTRIC MOTORS

8.3.1 Outgoing feeders from switchboards supplying electric motors rated over 0,5 kW are to be provided with short-circuit current and overload protective devices, and also with a no-voltage protection device unless the repeated automatic start of an electric motor is needed.

Overload and no-voltage protective devices may be fitted in motor starting apparatus.

8.3.2 Overload protective devices of continuously running motors are to disconnect the motor under protection when the loading is in the range of 105 to 125 per cent of the rated current.

The overload protective devices of electric motors may be replaced by a visual and audible alarm which is, in each case, subject to special consideration by the Register.

8.3.3 In supply circuits of electrically-driven fire pumps, the overload protective devices operating on the principle of electrothermal or temperature relays are not to be used. In this case, provision is to be made for a visual and audible alarm instead of the overload protective devices.

8.4 PROTECTION OF ELECTRIC DRIVES OF MODU STEERING GEAR

8.4.1 Only short-circuit current protection is to be provided for electric motors and control systems of electric or electrohydraulic steering gear.

A visual and audible alarm of the motor overload and any phase failure is to be provided.

8.4.2 Circuit breakers protecting direct-current motors against short-circuit currents are to have trip settings without a time delay at currents not lower than 300 per cent and not higher than 400 per cent of the rated current of the motor under protection, while those protecting alternating-current motors are to have trip settings without a time delay at currents over 125 per cent of the peak starting current of the motor under protection.

If fuses are used as protective devices, the rated current for the fuse is to be one grade of rating higher than it follows from the conditions specified for starting currents of electric motors.

8.4.3 Electric motors for the drives of MODU active steering means (thrusters) are to be provided with overload and short-circuit protective devices. The overload protective devices of the above drives are to be fitted with a visual and audible alarm of overloading and to disconnect the electric motor within the load range specified in 8.3.2 with the proper time delay.

Short-circuit protection is to meet the requirements of 8.4.2.

8.5 PROTECTION OF TRANSFORMERS

8.5.1 Short-circuit and overload protective devices are to be installed on the supply feeders of transformer primaries. Transformers rated up to 6,3 kVA may be protected by fuses only.

It is permitted for transformer overload protection to be replaced by a visual and audible alarm subject, in each case, to special consideraion by the Register.

8.5.2 Where transformers are intended for operation in parallel, provision is to be made for circuit breakers 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 is to be made for an interlock to prevent their operation in parallel in case of main switchboard sections isolation.

8.6 PROTECTION OF ACCUMULATOR BATTERIES

8.6.1 Short-circuit current protective devices are to be provided for accumulator batteries other than those which are intended to start internal combustion engines.

8.6.2 Each battery charging system is to be provided with protection against battery discharge due to a drop or loss of the charger output voltage.

8.6.3 For accumulator batteries intended for starting internal combustion engines, it is advised to fit disconnectors at the start of a circuit on the accumulator side to disconnect the batteries from consumers (the disconnectors may be fitted in one pole).

8.7 PROTECTION OF MEASURING INSTRUMENTS, AND CONTROL AND MONITORING DEVICES

8.7.1 Pilot lamps, as well as measuring and recording instruments are to be provided with short-circuit 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 device enclosure;

.3 the protection of the device circuit is rated for current not exceeding 25 A;

.4 a fault in the lamp circuit can not result in an interruption in the operation of an essential service.

Short-circuit protective devices or short-circuit current limiting devices are to be located as close as practicable to the terminals on the supply side.

8.7.2 Radio interference suppression capacitors in the circuits of main and emergency switchboards, generators, and essential electrical installations are to be protected against short-circuit currents.

8.7.3 The voltage coils of apparatus and devices for control and protection are to 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 fed from the circuit of the device whose protection is rated for current not exceeding 25 A.

8.7.4 No overload protecion and alarm is needed for voltage measuring transformers and control circuit transformers.

The switching-over of instrument current transformers is to be so arranged as to prevent the possibility of their secondaries being open-circuited.

8.8 PROTECTION OF POWER SEMICONDUCTOR UNITS

8.8.1 Provision is to be made for protecting power semiconductor units from internal and external overvoltage.

8.8.2 Semiconductor element units are to be protected against a short-circuit. The protection of separate diodes and thyristors is to be isolated from the protective load circuit.

8.8.3 Where only one consumer is available, a common protection for a load and semiconductor element units is permitted.

8.9 RESIDUAL CURRENT DEVICES (RCD)

8.9.1 To protect personnel against electrical shock and to protect some types of electrical equipment against single-phase earth fault residual current devices are to be used.

8.9.2 Residual current devices are to be fitted in the supply circuits of socket outlets intended to feed the portable equipment and in the supply circuits of cabin socket outlets as well as the socket outlets in public and other spaces with a voltage exceeding standard safety value (50 V).

8.9.3 Residual current devices are to be set to operate at the zero sequence current within the following limits:

30 mA – for consumers with double or reinforced insulation;

10 mA – for consumers with standard insulation.

8.9.4 For essential electrical equipment installation of the residual current devices are not permitted.

9 EMERGENCY ELECTRICAL INSTALLATIONS

9.1 GENERAL

9.1.1 Every MODU or FOP is to be provided with the self-contained emergency and emergency temporary sources of electrical power. As the emergency source, a diesel-generator is to be used while as the temporary emergency source, the system of accumulator batteries with an automatic charging device supplied from the main switchboard busbars.

9.1.2 Where the main source of electrical power along with its switchgear and control systems is fully independent of the switchgear and control systems in other spaces so that a fire or another accident in one of those spaces will not disrupt normal supply of the unit from other sources, then the separate emergency source of electrical power may not be installed provided that:

.1 there are at least two generators, meeting the requirements of this Part, in two or more spaces;

.2 existing generators are provided with automatic start systems which ensure the start of a standby generator and load take-over within 45 s;

.3 the location of each space containing generating sets meets the requirements of 9.2.1 to 9.2.3.

9.1.3 The power of an emergency source is to be sufficient to supply all those services whose simultaneous operation is essential for MODU or FOP safety in an emergency.

9.1.4 Facilities are to be provided for testing the complete emergency installation including automatic start devices of a diesel-generator.

9.1.5 An indicator activated at the discharge of any accumulator battery which is a temporary emergency or a standby source of power is to be fitted at the main machinery control room of the machinery installation or on the main switchboard.

9.1.6 Emergency sources of electrical power are to be provided with short-circuit protection only. A visual and audible alarm of a generator overload is to be provided for the emergency diesel-generator at the main machinery control room.

9.2 LOCATIONS FOR EMERGENCY SOURCES OF ELECTRICAL POWER

9.2.1 The locations of emergency sources of electrical power and of their transformers, if any, of temporary emergency sources of electrical power, an emergency switchboard and an emergency lighting switchboard are to be located above the uppermost continuous deck outside machinery casings and as far as possible from hazardous zones. The above spaces on MODU covered by the requirements of Part V "Subdivision" are also to be located at a height of at least 300 mm above the deepest damage waterline.

The exits from these spaces are to be easily accessible and to immediately lead to the exposed deck on which the emergency source of electrical power is installed.

9.2.2 The location of emergency sources of electrical power and of pertinent transformers, if any, of temporary sources of electrical power, an emergency switchboard and an emergency lighting switchboard in relation to the main sources of electrical power, their transformers and the main switchboard is to be such that a fire or another accident in the space of the main source of electrical power, of pertinent transformers and the main switchboard, and also in any machinery space of Category A will not cause damages to a supply system, and to the control and distribution of emergency power from the emergency source.

9.2.3 The locations of emergency sources of electrical power and of pertinent transformers, of temporary sources of electrical power, an emergency switchboard and emergency lighting switchboard are not to be adjacent to the machinery and boiler spaces and to the spaces of the main source of electrical power, pertinent transformers, and the main switchboard.

9.2.4 An emergency switchboard is to be installed as close as possible to the emergency source of electrical power, i.e. in one space with a diesel-generator excepting the case where such location affects switchboard functioning.

All starting and charging devices as well as starter accumulator batteries for an emergency set with due regard for fulfilment of the requirements given in 1.3.2, are to be located in the same space.

9.2.5 The space containing an emergency generating set is to be provided with heating appliances to ensure the temperature sufficient for trouble-free starting of the emergency set, and with ventilation for adequate air supply to operate the diesel-generator under the full load with the space closed.

9.3 EMERGENCY SOURCES OF ELECTRICAL POWER

9.3.1 The MODU or FOP emergency sources are to provide a supply for the following services for a period of 18 h:

.1 emergency lighting for:

all corridors, stairways and exits from service spaces as well as personnel lift cars and personnel lift trunks;

machinery spaces and generating sets spaces;

all local control stations as well as the main and emergency switchboards;

emergency diesel-generator spaces;

the bridge and reserve control stations and spaces associated with control of industrial process and machinery essential for maintaining this process, as well as the spaces containing devices for the emergency disconnection of electrical equipment;

the wheelhouse and radioroom (if any);

stowage positions for emergency and fireman's outfit, and positions where manual fire alarms are fitted;

the spaces for MODU steering gear and thrusters;

positions at the fire and sprinkler pumps, at the emergency bilge pump and at their starting positions;

helicopter hangars and helicopter landing decks;

gyrocompass and other navigation equipment spaces;

medical rooms;

.2 electric drives and alarm systems intended for life-saving appliances and personnel evacuation;

.3 electric drives and control systems of the blowout preventer and of the gear disconnecting the MODU or FOP from the well head arrangement;

.4 electric drives and control systems of permanently installed diving equipment;

.5 electrical arrangements whose functioning is essential while the MODU or FOP is abandoned by personnel;

.6 navigation and other lanterns required by the International Regulations for the Prevention of Collisions at Sea, in force;

.7 all internal communication means as well as a general alarm system;

.8 radio 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;

.9 fire and gas detection and alarm systems;

.10 daylight signaling lamps, sound signal means (whistles, gongs, etc.), a manual call signal for responsible personnel and other kinds of alarms required under emergency conditions;

.11 one of fire pumps and the electrical equipment ensuring the operation of foam generators specified in Part VI "Fire Protection" of MODU/FOP Rules;

.12 for a period of 96 h, all clearance flashing lanterns and electrical sound signals required for marking of a MODU or FOP;

.13 electric drives of watertight and fire doors with their indicators and alarms;

.14 electric drives of ballast pumps, a ballast valve control system, a ballast and MODU condition indicating system which are necessary for emergency operations of submersible and semi-submersible MODU;

.15 other systems whose functioning will be recognized by the Register as essential for the safety of the MODU or FOP and the personnel on board.

9.3.2 The emergency source of electrical power is to ensure supplying during 3 h the emergency lighting of embarkation stations for boarding life-saving appliances on deck and overboard according to Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships.

9.3.3 The emergency source of electrical power is to ensure supplying the steering gear, if any.

9.3.4 The emergency source of electrical power is to be:

.1 driven by an internal combustion engine having the characteristics specified in Part IX "Machinery" of MODU/FOP Rules and fitted with an alarm system;

.2 started automatically upon the voltage loss in the mains, and also automatically connected to the emergency switchboard busbars, and the services referred to in 9.3.6 are to be automatically supplied from the emergency generator. The total time of starting and load take-over by the generator is not to exceed 45 s.

9.3.5 As a temporary emergency source of electrical power referred to in 9.1.1, an accumulator battery is to be used which is to operate without recharging, with voltage variations across its terminals within 12 per cent of rated voltage during the entire discharge period set in this Section.

9.3.6 The capacity of the battery serving as the temporary source of electrical power is to be sufficient for supplying the following services during 30 min:

.1 the emergency lighting and the necessary clearance and navigation lanterns according to 9.3.1.1, 9.3.1.6, 9.3.1.12 and 9.3.2;

.2 all internal communication and announcing systems required in an emergency;

.3 a general alarm system, a fire and gas detection system and an alarm on starting a fire-smothering system;

.4 daylight signaling lamps, sound signal means (whistles, gongs, etc.);

.5 a command broadcast apparatus or a loudspeaker system specified in 7.2.7;

.6 closing gear of watertight and fire doors, their position indicators and signals warning of their closure.

The services listed in 9.3.6.2 to 9.3.6.6 may not be supplied from the temporary source if they have their own accumulator batteries supplying them within the set time.

9.4 DISTRIBUTION OF ELECTRICAL POWER FROM EMERGENCY SOURCES

9.4.1 Under normal operational conditions, an emergency switchboard is to be fed from the main switchboard. The emergency switchboard feeder is to have protective devices against an overload and a short circuit fitted at the main switchboard.

Provision is to be made for a circuit breaker at the emergency switchboard which opens with a voltage loss on the main switchboard busbars.

Where the main switchboard is supplied from the emergency one, the circuit breaker at the emergency switchboard is to be fitted with at least short-circuit protective devices.

9.4.2 Where the emergency diesel-generator supplies non-emergency consumers in exceptional cases and for short periods of time, provision is to be made for:

.1 appropriate measures ensuring the operation of emergency arrangements under any emergency conditions;

.2 an automatic disconnection of the non-emergency consumers from the emergency switchboard to ensure the supply of emergency services in case of an accident (fire, flooding).

9.4.3 The consumers listed in 9.3.1 are to be supplied by separate feeders from the busbars of the emergency switchboard fitted with appropriate switchgear and protection. The supply of the consumers listed in 9.3.1.2 to 9.3.1.12 may be effected from an integrated bridge control console located at the unit's bridge control station and supplied according to 4.4.

9.4.4 In order to prevent an inadvertent or unauthorized disconnection of the services listed in 9.3.6, these are to be supplied via the special switchboard which will be accessible for authorized personnel only.

9.4.5 The cables feeding emergency consumers are to run so that the flooding of the consumers below the bulkhead deck does not interrupt the supply of other consumers above that deck.

9.4.6 The switchgears of emergency services are to be located above the bulkhead deck.

9.5 STARTING ARRANGEMENTS OF EMERGENCY DIESEL-GENERATORS

9.5.1 As starting arrangements of emergency diesel-generators may be used:

.1 an electric starter with its own accumulator battery and charging device;

.2 a compressed air system with its own independent air receiver;

.3 a hydraulic starting system;

.4 manual starting arrangements:

inertia starters;

manually charged hydraulic accumulators;

powder charge cartridges.

9.5.2 Each emergency diesel-generator is to be fitted with an automatic starting arrangement of the recognized type with a storage energy capability of at least three consecutive starts. A second source of energy is also to be provided for an additional three starts within 30 min unless manual starting can be demonstrated to be effective.

9.5.3 The charging devices of accumulator batteries and the electric drives of the machinery serving the compressed air or hydraulic starting systems of the emergency diesel-generator are to be supplied from the emergency switchboard by separate feeders.

9.5.4 An emergency generator is to be capable of being readily started at the temperature of 0 °C in the space of the emergency diesel-generator.

9.5.5 Compressed air starting arrangements of the emergency diesel-generator may be maintained by the main and auxiliary compressed air receivers, through a suitable non-return valve or by an emergency air compressor energized by the emergency switchboard.

9.5.6 All starting arrangements and charging devices of accumulators as well as the accumulators and other power storing devices for emergency diesel-generator starting are to be located in the emergency generator space and not to be used for other purposes.

9.5.7 When automatic starting of an emergency diesel-generator is not provided, as being unjustified, and it may be demonstrated by the effectiveness of other way of starting, for instance, by manual inertia starters, manual hydraulic accumulators or powder cartridges, then these arrangements are covered by the requirements in 9.5.2 excepting the requirements for automatic starting.

9.6 EMERGENCY STATIONS AND EMERGENCY SHUTDOWN FACILITIES FOR ELECTRICAL EQUIPMENT

9.6.1 Provision is to be made for at least two independent emergency control stations on board the MODU or FOP. One of these is to be located near the drilling operation station and another one, in an appropriate manned space outside hazardous zones.

9.6.2 Emergency control stations are to be provided with:

manual contactors of a general alarm system;

independent communication facilities between these stations and all other control stations (the MODU or FOP bridge control station, the main control station of the machinery installation, etc.) ensuring the unit's safety;

means for the emergency shutdown of electrical equipment according to 9.6.3.

9.6.3 In an emergency, when, due to an uncontrolled well manifestation, hazardous zones fall outside the limits specified in 2.9, emergency switching means at emergency control stations are to provide the possibility of electrical equipment switching-off in the following sequence:

ventilation systems of spaces excepting the fans providing an air inflow essential for operation and cooling of the sets of the main source of electrical power;

all the electrical equipment outside the hazardous zone 1;

the sets of the main source of electrical power;

the services supplied from the emergency source of electrical power excepting the services specified in 9.3.6;

the emergency diesel-generator.

9.6.4 Irrespective of the remote emergency switching means specified in 9.6.3, when a fire-smothering system is activated, the ventilation of the space served is automatically and simultaneously to be switched off.

9.6.5 The sequence of the machinery switching-off specified in 9.6.3 may be altered depending on the specific emergency situations. The recommended sequence is to be given in the special instructions for operations in emergency situations.

9.6.6 The emergency switching-off system is to be designed so as to minimize the possibility of its inadvertent switching-off or switching-off due to damages or mistakes in the control operations sequence.

9.6.7 Upon the emergency switching-off specified in 9.6.3, the following explosion-proof electrical equipment located in non-enclosed spaces and approved for operation within zone 2 is to continue functioning:

.1 emergency lighting specified in 9.3.6.1 within 30 min;

.2 preventer emergency control system;

.3 general alarm system;

.4 communication radio equipment supplied from its own accumulator batteries.

10 ELECTRICAL MACHINES

10.1 GENERAL

10.1.1 The materials of electrical machine shafts (of generators and motors) are to meet the requirements of Part XIII "Materials" of MODU/FOP Rules.

10.1.2 Excitation systems and automatic voltage regulators of alternating-current generators in the mode of a sustained short circuit are to maintain at least three-times the rated current within 2 s.

10.1.3 The generators of the main source of electrical power, the machines of the electrical propulsion installation and, when justified, other essential electrical machines onboard the MODU or FOP are to have heating arrangements to maintain their temperature at least 3 °C above the ambient temperature.

10.1.4 Rotors and armatures of alternating and direct current machines are to be capable of withstanding for 2 min, without damage and permanent set, the following increased rotational speed:

.1 generators, rotating converters and electric couplings and brakes — 120 per cent of the rated rotational speed, but at least by 3 per cent more than the maximum rotational speed during an equalizing (transient) process;

.2 series-wound motors — 120 per cent of the maximum permissible rotational speed as indicated on the rating plate, but not less than 150 per cent of the rated rotational speed;

.3 all the motors other than the above mentioned — 120 per cent of the maximum rotational speed.

10.1.5 Where a machine is so designed that after installation in the engine room its bottom portion is positioned below the floor level, ventilation air intake is not to be through the bottom portion of the machine.

10.1.6 Provision is to be made for prevention of moisture and condensate accumulation in electrical machine housings. Where liquid-cooled heat exchangers are used in electrical machines, their design is to be such that, in case of a leakage, a coolant could not permeate into the electrical machine. In this case, an alarm of a heat exchanger leakage is to be provided.

10.2 TERMINAL BOXES, SLIP RINGS, COMMUTATORS AND BRUSHES

10.2.1 Electrical direct current machines rated at 200 kW and over are to be provided with sight holes to enable observation of a commutator and brushes without removing the lids.

10.2.2 The permissible wear value for commutator segments or slip rings is to be indicated on their sides. It is to be taken equal to at least 20 per cent of the commutators or slip rings height.

10.2.3 For armatures of over 1000 kg in mass, provision is to be made to allow reconditioning of the commutator without the removal of the armature from a machine.

10.2.4 Electrical machines are to have terminal boxes for the handy connection of external cables. The terminals are to be appropriately marked, reasonably sound and protected against an inadvertent contact with the housing and between poles or phases.

10.2.5 Terminal boxes are to have sufficient air gaps between the current-carrying parts of the terminal block and housing. The terminal boxes are to be so dimensioned that convenient arrangement of the terminations of finish leads and connected cables is ensured.

10.2.6 The position of brushes in direct current machines is to be clearly and indelibly marked. The direct current machines are to be made so that they could operate in all modes with the permanent arrangement of brushes.

10.2.7 Commutator-type machines are to be capable of operating practically without sparking at any load from zero to rated value. No sparking is to develop at the specified overloads, reversal and start of the machines, to such an extent as to cause damage to brushes or commutators.

10.3 BEARINGS

10.3.1 Bearings are to be so designed as to avoid the opportunity of oil splashing or leaking along the shaft and coming into contact with the machine windings or live parts.

10.3.2 Plain bearing casings are to be fitted with a hole for excessive lubricating oil drain and with a lid in the upper part of the casing. Oil level indicators are to be provided on the machines rated at 100 kVA and over.

10.3.3 A pressure-lubricating system is to be fitted with a device for monitoring the pressure of the lubricating oil entering the bearing.

10.3.4 For electrical machines with plain bearings, measures are to be taken to prevent the flow of stray currents through the bearings.

10.4 TEMPERATURE DETECTORS

10.4.1 Stators of alternating current machines rated at over 5000 kW, or having a core length over 1000 mm are to be provided with temperature detectors located in those parts of the machine where the highest temperatures may be expected.

10.5 ALTERNATING CURRENT GENERATORS

10.5.1 General.

10.5.1.1 Each alternating current generator is to have a separate independent system of automatic voltage regulation.

10.5.1.2 Malfunctions in the voltage regulation system of generators are not to result in overvoltages at its terminals above the values stipulated by the maximum design excitation capacity.

10.5.1.3 Alternating current generators are to have such a design that after heating up to a steady temperature corresponding to a rated load they could withstand a current overload of 50 per cent within 120 s.

10.5.1.4 Alternating current generators are to possess adequate excitation capacity to maintain a rated voltage with an accuracy of 10 per cent within 2 min at generator overcurrent equal to 150 per cent of a rated value and at a power factor of 0,6.

10.5.2 Voltage regulation.

10.5.2.1 Alternating current generators are to have automatic voltage regulation systems ensuring maintenance of the voltage within (2,5 per cent (up to (3,5 per cent for emergency generators) of a rated value at all load changes from no-load to rated load values at a rated power factor. A rotational speed therewith is to be within the range specified in Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships.

10.5.2.2 A sudden change in the balanced load of a generator running at a rated rotational speed and rated voltage, under given current and power-factor conditions, is not to result in a drop of voltage below 85 per cent or a rise over 120 per cent of a rated value. Following such a change, the generator voltage is to be restored to ± 3 per cent of a rated value within not more than 1,5 s. For emergency sets, these values may be increased up to 5 s in time and ± 4 per cent of a rated value in voltage.

Where no precise data are available on peak values of a sudden load being added to the existing generator load, these may be taken equal to a load of 60 per cent of a rated current at a power factor of 0,4 and less, which is connected at idle speed and then disconnected. The rotational speed therewith is to be within the range specified in Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships.

10.6 DIRECT CURRENT GENERATORS

10.6.1 General.

10.6.1.1 Shunt-wound and separately excited direct current generators are to be fitted with automatic voltage regulators.

10.6.1.2 Direct current generators are to have such a design that after heating up to a steady temperature corresponding to a rated load, they could withstand a current overload of 50 per cent within 15 s.

10.6.2 Voltage regulation.

10.6.2.1 Manual voltage regulators of direct current compound-wound generators are to enable reduction of no-load voltage, with the generator cold, by not less than 10 per cent below the rated generator voltage with due regard to the increased revolutions of the prime mover running at no load.

10.6.2.2 Manual voltage regulators are to be so designed that the voltage increases when their controls are rotated clockwise.

10.6.2.3 If the voltage of the generator with a shunt field winding (or a shunt and stabilized series field winding) is set to a rated value at a full load, then with the reduction of a generator down to a no-load running, the generator voltage is not to step up by more than 15 per cent of the rated value.

10.6.2.4 The voltage regulation devices specified in 10.6.2.1 are to have the regulation accuracy up to ± 1 per cent for generators rated up to 100 kW and up to $\pm 0{,}5$ per cent for generators of rating exceeding 100 kW. The above accuracy of these independent devices is to be maintained in a cold and hot state, and also at any load within the operating loads range of a generator.

10.6.2.5 Direct current sets comprising compound-wound generators are to have such external characteristics that the voltage of a hot generator set to the rated value with an accuracy of ± 1 per cent at 20 per cent of the load does not vary at a full load by more than $\pm 1{,}5$ per cent for generators rated at 50 kW and over, and by more than 2,5 per cent for generators of lower output.

10.6.2.6 Voltage variations in a compound-wound generator running at 20 per cent to 100 per cent of the rated load are not to exceed the following limits:

.1 ± 3 per cent for generators rated at 50 kW and over;

.2 ± 4 per cent for generators rated over 15 kW but less than 50 kW;

.3 ± 5 per cent for generators rated at 15 kW and less.

10.6.2.7 Direct current sets comprising shunt-wound generators are to have such external generator characteristics and automatic voltage regulators that the voltage is maintained with an accuracy of $\pm 2{,}5$ per cent of the rated value at all load variations from zero to the rated load.

10.7 ELECTRIC MOTORS

10.7.1 Electric motors are to have such a design that they could develop increased torques specified in Table 10.7.1 without a stop or sudden change of a rotational speed.

10.7.2 It is recommended to provide for built-in temperature sensors in electric motors for short-time and intermittent duties.

Table 10.7.1

Nos	Motor type	Torque overload, per cent	Duration, s
1	Synchronous and induction motors with $I_{start} = 4{,}5 I_{rated}$	50	15
2	Induction motors for continuous and intermittent duties	60	15
3	Induction motors for short-time duty with varying load	100	15
4	Direct current motors	50	15

10.7.3 In electric motors of anchor and mooring machinery drives, it is recommended to use overload protection as built-in temperature sensors so selected that a protection system switches off the electric motor when the temperature allowable for insulation of machine windings is exceeded by not more than 30 per cent.

The leads of sensors are to be located in an easily accessible place.

10.8 ELECTROMAGNETIC BRAKES

10.8.1 The brake is to operate when the brake-operating coil becomes de-energized.

10.8.2 A 30 per cent voltage drop below the rated value is not to cause a hot brake to operate.

10.8.3 Electromagnetic brakes are to make possible manual release.

10.8.4 Electromagnetic brakes are to be fitted with at least two pressure springs.

10.8.5 The shunt field windings of a compound-wound electromagnetic brake are to be capable of holding off the brake even when no current flows through the series winding.

10.8.6 The shunt field windings of electromagnetic brakes are to be so made or protected that they can be safe from damages at overvoltages occurring when they are being disconnected (see also 5.4.3).

11 TRANSFORMERS

11.1 GENERAL

11.1.1 The requirements of this Section apply to power transformers mentioned in 3.3.

The additional requirements for transformers with voltages over 1000 V are given in Section 18.

11.1.2 It is allowed to use both dry-type and liquid-immersed (transformer oil) transformers on-board the MODU or FOP. Where transformers are located inside spaces, they are to be of the dry- and natural-cooled type. The application and installation of other type transformers in spaces is subject, in each case, to special consideration by the Register.

11.1.3 The transformers used for operation with semi-conductor converters are to be designed with due regard to potential distortions both in a supply frequency and voltage sinusoidalness.

11.1.4 Transformers are to have electrically-separated windings for primary and secondary voltages.

11.1.5 Where oil-immersed transformers are used, the following is to be taken into account:

.1 transformers are to be of the leak-proof type, or

.2 transformers are to be made so as to prevent the potential liquid overflow or leakage under all conditions of unit's operation including the maximum list and trim;

.3 compensating devices of a cooling liquid for transformers are to be designed so as to prevent the potential leakage of the cooling liquid at any temperature variations;

.4 the cooling liquid is not to be toxic and not to sustain combustion;

.5 provision is to be made for an alarm system on the maximum temperature of the cooling liquid and for the protection on presence of a gas in the cooling liquid.

11.1.6 Where forced cooling of transformers is used, provision is to be made for their potential operation at the reduced output if cooling pumps or fans fail. In this case, an alarm is to be provided as well.

11.2 OVERLOAD, VOLTAGE VARIATION AND OPERATION IN PARALLEL

11.2.1 Transformers are to withstand 10 per cent overloads for 1 hour and 50 per cent overloads for 5 min as well.

11.2.2 Voltage variation at an active load between the zero and rated load is not to exceed 5 per cent for transformers rated up to 6,3 kVA per phase and 2,5 per cent for transformers of higher rating.

11.2.3 Transformers intended for operation in parallel are to have their winding connections grouped together, the same transformation ratios, and their short-circuit voltages are to be such that the load on any transformer does not deviate from the value corresponding to the proportional part of each transformer power output by more than 10 per cent of the rated current for a given transformer.

11.2.4 Nominal capacities of transformers for operation in parallel are not to differ from one another more than twice.

12 POWER SEMICONDUCTOR UNITS

12.1 GENERAL

12.1.1 In power semiconductor units, use is to be made of semiconductor elements of silicon type. Use of other type elements is allowed by the special agreement with the Register.

12.1.2 To prevent condensation in units based on semiconductor devices whose dissipation power is over 500 W, provision is to be made for heating to maintain the temperature at least 3 °C above the ambient air temperature.

12.1.3 Power semiconductor units are to be provided with air cooling (natural or forced). Fluid cooling is allowed only by the special agreement with the Register.

12.1.4 For power semiconductor units with forced cooling, provision is to be made for the protection reducing or disconnecting the load if the cooling is switched off.

An audible and visual alarm indicating the excess of the maximum permissible temperature of a cooling medium at the system outlet prior to the protection activation is to be provided.

12.2 PERMISSIBLE PARAMETERS OF VOLTAGE DISTORTION

12.2.1 The harmonic distortion factor KU for the unit's mains due to the operation of power semiconductor units is not to exceed 10 per cent.

The use of power semiconductor units which cause the distortion of a sinusoidal voltage curve by more than 10 per cent is subject to special consideration by the Register.

The harmonic distortion factor is to be determined by the formula given in 2.2.1.3.

12.2.2 The factor of the maximum relative deviation of an instantaneous voltage value from the 1st harmonic value is not to exceed 30 per cent.

The factor ΔU_w is to be determined by the formula

$$\Delta U_w = \Delta U_m / (\sqrt{2} U_1) \qquad (12.2.2)$$

where ΔU_m = maximum deviation value,
U_1 = effective value of the 1st harmonic of voltage.

12.3 CONTROL AND ALARM SYSTEMS

12.3.1 Power semiconductor units are to be provided with a visual alarm for connection and disconnection of power and control circuits.

12.3.2 The power section of semiconductor units is to be electrically isolated from a control system.

12.3.3 The long-term currents deviation in parallel branches of semiconductor units is not to exceed 10 per cent of an average current.

12.3.4 The operation of power semiconductor units is not to be disrupted by the failure of particular semiconductor elements. Where the load on the particular semiconductor elements exceeds permissible values, it is automatically to be reduced.

When some semiconductor elements fail, an audible and visual alarm is to be activated.

12.4 MEASURING INSTRUMENTS

12.4.1 Power semiconductor units are to be fitted with appropriate instruments for measuring the main input and output parameters of the unit.

12.4.2 The rated values of parameters are to be marked on instrument scales. Where a converter is force-cooled, the maximum permissible temperature is to be marked on the cooling air thermometer scale.

13 ACCUMULATOR BATTERIES

13.1 GENERAL

13.1.1 Accumulator batteries are to be so made 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 per cent of rated capacity for acid batteries and 25 per cent for alkaline batteries.

13.1.2 Battery containers and closures for holes are to be so designed as to prevent spilling and splashing of an electrolyte when the container is inclined on any side to an angle of 40° from the vertical.

Closures are to be made of durable and electrolyte-resistant material. Closures design is to prevent the build-up of excessive gas pressure inside the battery.

13.1.3 The mastics used are not to change their properties or to deteriorate at ambient temperature variations from −30 °C to +60 °C.

13.1.4 The materials used for making battery boxes are to be electrolyte-resistant. Individual cells placed in boxes are to be secured so as to prevent their relative displacements.

13.1.5 For the accumulator batteries intended for use as the electrical power source to supply the essential and emergency consumers a record book of the accumulator battery condition monitoring and maintenance is to be provided. This record book is to contain as a minimum the following information on the accumulator battery:

type and description of the accumulator battery;

voltage and capacity;

location;

description of the equipment and systems for which the accumulator battery is intended;

data on planned periodic maintenance or replacement;

data on the latest maintenance or replacement;

details of the accumulator battery manufacturer and permissible period of storage — for the accumulator batteries intended for replacement and stored separately.

13.1.6 The unit is to carry an instruction for replacement of accumulator batteries which is to indicate that the new accumulator battery is to have equivalent (identical) characteristics.

13.1.7 In case when a tight accumulator battery is replaced by a ventilated one, the space where accumulator battery is to be installed is to have adequate ventilation, as indicated in 13.4.

13.1.8 The basic data of the accumulator battery maintenance log book are to be included into the unit's safe maintenance system documents which are to be supervised by the Register.

13.2 ARRANGEMENTS OF ACCUMULATOR BATTERIES

13.2.1 Batteries for a voltage above the safety one, as well as batteries having a charge capacity over 2 kW calculated on the basis of the maximum charging current and the rated voltage, are to be located in special battery compartments accessible from the deck, or in special boxes installed on the deck and provided with heating and ventilation.

Batteries having a charge capacity within the range of 0,2 to 2 kW may be installed in boxes or cabinets located in MODU or FOP special spaces.

Accumulator batteries intended for the electric starting of internal combustion engines, except for emergency sets, may be installed in machinery spaces in special boxes or cabinets adequately ventilated.

Batteries having a charge capacity under 0,2 kW, and also non-maintained leak-proof batteries of unlimited charge capacity may be installed in any space, other than accommodation spaces, provided they are protected against touching current-carrying parts, water effect and mechanical damages, and do not adversely affect the surrounding equipment.

13.2.2 The acid and alkaline batteries are not to be located in one space or in one box. The vessels and instruments intended for batteries with different electrolytes are to be installed separately.

13.2.3 The inside of battery compartments or boxes, as well as all structural elements which may be subjected to adverse effects of an electrolyte or a gas, are to be suitably protected.

13.2.4 Accumulator batteries, and also individual cells are to be properly secured. If installed on racks in two or more tiers, these racks are to have a clearance of at least 50 mm on the face and back sides for air circulation, and the distance from the deck to the plugs in the upper tier of the cells is not to exceed 1500 mm.

13.2.5 Installing accumulator batteries or individual accumulators (cells), provision is to be made for fitting linings and spacers between them, which ensure a clearance of not less than 15 mm on all sides for air circulation.

13.2.6 Caution notes indicating the danger of explosion are to be provided on the doors leading to the battery compartment or nearby, and also on the boxes containing the accumulators.

13.3 HEATING

13.3.1 The accumulator compartments and boxes in which a temperature in service may go below 5 °C are to be fitted with a heating system. The heating is allowed to be effected by the heat from adjacent spaces, and also with water and steam radiators located inside the battery compartments or boxes.

13.3.2 The heating system valves are to be located outside the battery compartments.

13.3.3 The MODU or FOP general air-conditioning system is not to be used as the main system for heating the battery compartments.

13.4 VENTILATION

13.4.1 Battery compartments and boxes are to have adequate ventilation to prevent potential accumulation of explosive mixtures.

13.4.2 Battery compartments provided with mechanical ventilation are to have devices, which prevent the possibility of switching on the accumulators for charging prior to the ventilation switch-on.

Charging cycle is automatically to be discontinued if the ventilators stop.

13.5 CHARGING OF ACCUMULATOR BATTERIES

13.5.1 Provision is to be made for charging facilities to charge the accumulator batteries of essential services within 8 h. Where an additional battery is used instead of the one being charged, the charging time may exceed 8 h.

13.5.2 The charging facilities are to have means for measuring the voltage across battery terminals and the charging current, as well as the discharge current for temporary emergency sources of electrical power.

13.5.3 Provision is to be made for facilities to charge the accumulators of portable accumulator-fed lights and spare accumulator-fed navigation lights.

13.6 INSTALLATION OF ELECTRICAL EQUIPMENT IN BATTERY COMPARTMENTS

13.6.1 Except for safe-type lighting fixtures and cables terminated at accumulators and lighting fixtures, no other electrical equipment is to be installed in battery compartments.

13.6.2 Cables terminated at accumulator batteries and lighting fixtures may run openly provided they have metal armour or braid covered with a non-metal sheath and this armour or braid is reliably earthed at both ends.

13.7 ELECTRICAL STARTERS FOR INTERNAL COMBUSTION ENGINES

13.7.1 Number of starter batteries.

13.7.1.1 For electrically-started internal combustion engines, irrespective of their number, it is permanently to be installed:

at least two starter batteries for each two internal combustion engines with a potential switching of each battery for starting both engines;

at least two common starter batteries for starting all engines. In addition, provision is to be made for a permanent switching system that ensures the possible use of any battery for starting any engine in the group served by this battery.

13.7.2 Battery characteristics.

13.7.2.1 Each starter battery is to be designed to withstand a discharge current in a starter duty that corresponds to the maximum current through the most powerful starting electric motor.

13.7.2.2 The capacity of each battery is to be adequate for six starts of an internal combustion engine in the ready-for-start condition, and for at least three starts of each from two or more engines.

13.7.2.3 Calculating battery capacity, the duration of each start is to be assumed not less than 5 s.

13.7.3 Charging facilities.

13.7.3.1 The charging facility of starter batteries is to be supplied by a separate feeder from the main switchboard even if the battery is charged from the internal combustion engine-driven generator.

14 ELECTRICAL APPARATUS AND ACCESSORIES

14.1 ELECTRICAL APPARATUS

14.1.1 General.

14.1.1.1 The design of switches with renewable contacts is to be such that renewal of the contacts could be made with standard tools without dismantling the switch or its main components.

14.1.1.2 All disconnectors and switches, except those for cabins, are to be fitted with mechanical or electrical contact position ("ON" - "OFF') indicators located in the place from which the apparatus is activated by the operator.

14.1.1.3 The positions of controller and master controller drums are to be rigidly locked by mechanical means, location in zero position being more rigid than elsewhere.

The controller and master controller drums are to be fitted with a scale and an indicator of "ON" position.

14.1.1.4 Control gear, other than used for continuous smooth regulation, is to be made so that the end and intermediate fixed positions are easy to sense at various control steps while the movement beyond the end positions is to be impossible.

14.1.2 Manually operated controls.

14.1.2.1 The direction of movement of manual controls of switchgear or control gear is to be such that the clockwise rotation of a handle (handwheel) or the displacement of a handle (lever) up or forward corresponds to apparatus closing, electric motor starting, rotational speed increase, voltage stepping-up, etc.

When hoisting or lowering arrangements are under control, the clockwise rotation of a handle (handwheel) or the displacement of a handle (lever) toward the operator is to correspond to hoisting while the counterclockwise rotation or displacement away from the operator, to lowering.

14.1.2.2 Switch push buttons are to be made so that they cannot be actuated accidentally.

14.1.3 Electrically operated gear.

14.1.3.1 The actuator of circuit breakers and other switches is to 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 open position only.

14.1.3.2 An electric actuator is to provide for reliable closing of the apparatus at the voltage supply within 85 to 110 per cent of the rated value, and in case of an alternating current, at frequency deviations within ± 5 per cent of the rated value at the ambient temperature of 45 °C and with the heated actuator winding.

14.1.3.3 The operation of an actuator at 110 per cent of the rated voltage is not to result in damages to the switch or in excessive effect on contacts affecting the commutation capability of the apparatus. The above requirement with relation to electro-magnetic contactors is to be fulfilled when the contactor is being closed at the ambient temperature of - 10 °C and with the heated coil winding.

14.1.3.4 A voltage drop down to 70 per cent of the rated actuator supply voltage is not to cause main and auxiliary contacts opening or decrease of contact pressure at the ambient temperature of 45 °C and with the heated actuator winding.

14.1.3.5 The design is to provide for the possibility of the manual control of an electrically-operated switch.

14.1.4 Coils.

14.1.4.1 A conductor or a lug is to be attached to a coil winding in such a way that the forces from the conductor connected are not transmitted to the coil turns. The taps of voltage coils are to be made of flexible multiwire conductor, except when contact terminals are directly secured to the coil frame.

14.1.4.2 The coils of electromagnetic apparatus are to bear notations giving the particulars of their characteristics.

14.1.5 Fuses.

14.1.5.1 Fuse link housings are to be of the totally enclosed type. The melting-down of a fusible element is not to cause an arc ejection to the outside, sparking or any other harmful effect upon the nearby parts of electrical equipment.

14.1.6 Resistors.

14.1.6.1 Resistor elements are to be easily replaceable, in sections or in total.

14.1.6.2 Ballast resistor blocks are to be so arranged and ventilated that they do not heat other devices beyond the permissible limits.

14.1.6.3 The additional requirements for earthing circuits of networks with voltage over 1000 V are specified in Section 18.

14.2 WIRING ACCESSORIES

14.2.1 General.

14.2.1.1 The enclosures of accessories and fittings are to be made of materials of adequate mechanical strength which are corrosion-resistant or properly protected against corrosion and, at least, flame-retardant. The enclosures of accessories and fittings to be installed on the exposed deck, in refrigerated spaces and humid locations are to be made of brass, bronze or equivalent material, or of plastics of proper quality. Where steel or aluminium alloys are used, the proper anti-corrosive protection is to 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 attached, are to be made of materials that do not evolve gases ignited from an electric spark at a temperature of up to 500 °C inclusive.

14.2.1.3 The lighting fixtures to be mounted on or close to combustible materials are to be designed so as to prevent their heating over 60 °C (see also 6.5.8).

14.2.2 Lampholders.

14.2.2.1 The design of lampholders fitted with a screw cap is to 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 is to be marked to indicate the rated voltage, and also the maximum allowable current or power.

14.2.3 Plug-and-socket connectors.

14.2.3.1 The pin jacks of socket outlets are to be so designed 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 over 10 A are to be cylindrically shaped, solid or hollow.

14.2.3.3 Socket outlets and plugs for voltages exceeding the safety one are to have contacts for connecting the earthing conductors of incoming cables from current consumers.

14.2.3.4 Socket outlets are to be so designed that the proper protection degree is ensured regardless of whether the plug is in or out of the socket outlet.

14.2.3.5 Socket outlets rated over 16 A are to be provided with built-in switches. Provision is also to be made for interlocking such socket outlets to prevent the possibility of the plug being inserted or withdrawn while the socket switch is in the "ON" position.

14.2.3.6 Where socket outlets are not interlocked, the clearance between contacts in air and across the insulation surface is to be such that no short circuit is possible due to arcing over when the plug is withdrawn while carrying a load by 50 per cent above the rated current at the rated voltage.

14.2.3.7 Socket outlets and plugs are to be so designed that it is not possible to insert current-carrying pins into the earthing jack, and the design of the outlets intended for connecting motors (devices) whose rotation direction depends on the change of phases or poles sequence, additionally to exclude the possibility of the sequence change. When the plug is inserted into the socket outlet, the earthing part of the plug is to make contact with the earthng part of the socket outlet before connecting the live pins.

14.2.3.8 No fuses are allowed to be fitted in socket outlets and plugs.

14.2.3.9 The socket outlets design is to rule out the possibility of connection to them of the plugs of consumers designed for a lower voltage.

14.2.3.10 Socket outlets on exposed decks are to be mounted with their face looking downward, and the cable connected to them is not to get through the coamings of doors or through other openings to be closed which open into hazardous spaces and areas.

15 ELECTRICAL COOKING AND HEATING APPLIANCES

15.1 GENERAL

15.1.1 Only stationary-type electrical cooking appliances are permitted for use.

15.1.2 Electrical cooking appliances are to be supplied from the main switchboard or from distribution boards intended for this purpose, and also from lighting switchboards with regard to the requirements of 6.2.1.

15.1.3 The supporting structural parts of electrical cooking appliances, as well as the internal surfaces of enclosures are to be made of non-combustible materials.

15.1.4 In heated condition, a permissible leakage current is not to exceed 1 mA per 1 kW of the rated power for any separately connected heating element or 10 mA for the appliance as a whole.

15.1.5 Electrical cooking appliances are to be so designed that the temperature of their parts used by the personnel or which may be touched, does not exceed the values specified in Table 15.1.5.

Table 15.1.5

Nos	Item	Permissible temperature, °C
1	Control handles for prolonged use:	
	metallic	55
	non-metallic	65
2	Same, but for short-time use:	
	metallic	60
	non-metallic	70
3	Enclosures of electrical cooking and heating appliances in spaces at the ambient temperature of 20 °C	80
4	Air coming out from heating appliances into the heated space	110

15.2 HEATING APPLIANCES

15.2.1 Electrical heating appliances intended for space heating are to be stationary. These are to be provided with devices disconnecting the supply source if the temperature rise of the appliance enclosure exceeds the permissible limit.

15.2.2 Heating appliances are to be installed according to the requirements of 2.1.13, Part VI "Fire Protection" of MODU/FOP Rules.

15.2.3 If heating and cooking appliances are not provided with built-in disconnecting devices, then such devices are to be installed in the space in the immediate vicinity of these appliance enclosures. Switches are to disconnect power supply at all poles or phases.

15.2.4 The design of electrical heating appliance enclosures is to prevent the possibility of any objects being placed upon them.

15.2.5 Stationary heating appliances rated at 380 V and allowed for use in accordance with Table 4.1.5 are to be protected against access to live parts without the aid of special tools. The enclosures are to have notices giving the voltage value.

15.2.6 Electrical cooking appliances being part of galley equipment are to be so designed as to prevent the possibility of the kitchenware contact with live parts, and a short circuit or damage to insulation due to a liquid overflow.

15.3 PETROLEUM PRODUCT HEATERS

15.3.1 Petroleum products (fuel oil and lubricating oil) having a flash point above 60 °C may be heated by means of electric heaters provided the requirements of 15.3.2 and 15.3.3 are fulfilled.

15.3.2 Heaters with heating cables used on pipelines are to be fitted with temperature control means, a visual alarm of operation modes, and also with a visual and audible alarm of malfunctions and the temperature rise above the permissible level.

15.3.3 Heaters in tanks are to be of the indirect heating type and fitted with means for control of the temperature of the medium heated, with sensors of heating coils surface temperature, with low level indicators and means for the disconnection of power supply to the heaters in case the upper temperature limit and the lowest permissible level are exceeded.

15.3.4 Irrespective of the type of the electric device for heated medium temperature control, a manually disengaged device for de-energizing the heaters on reaching the heating coil surface temperature of 220 °C is to be provided.

15.3.5 Heating cables and electric surface heaters are to be supplied by separate feeders with a rated current not exceeding 63 A.

15.3.6 Suitable protection against mechanical damages is to be provided for heating cables and surface heaters. Appropriate notices are also to be provided to warn the personnel about the prevention of any mechanical damages to the pipelines fitted with the heating cables.

15.3.7 Heating cables and surface heaters in hazardous areas may be used only with the appropriate explosion protection type confirmed with competent body certificates.

15.4 ARRANGEMENTS WITH HEATING CABLES

15.4.1 Arrangements with heating cables for ice removal and icing protection are to be provided for ship's equipment and spaces intended for:

designed functioning of an installation (process equipment);

maintenance of steerability;

maintenance of stability;

safety of crew (process pads, stairways, rails, rafts, lifeboats, etc.).

15.4.2 Heat output of such arrangements is to be at least:

300 W/m^2 for the spaces of open decks, helidecks, stairways and gangways;

200 W/m^2 for superstructures;

50 W/m^2 for deck rails with internal heating.

Heat output for other areas and spaces is subject to special consideration by the Register in each particular case.

15.4.3 To provide efficient heating particular attention is to be given to heat transfer from a cable to the equipment (spaces) to be heated.

15.4.4 Switchboard for the above arrangements is to be equipped with:

wattmeter or ammeter for total load indication;

nameplate indicating the design load for each circuit, as well as for the switchboard on the whole;

earth fault monitoring unit for each circuit with warning alarm;

signal lamps indicating switching-on of the load for each circuit.

15.4.5 Two-conductor heating cables are to have overload protection of 125 per cent of rated current. For self-regulating cables the overload protection may be dispensed with.

16 CABLES AND WIRES

16.1 GENERAL

16.1.1 The requirements of this Section apply to power cables and wires for voltage up to 1000 V and to control and signal cables. Additional requirements for cables for voltage over 1000 V and the conditions of their running are given in Section 18.

16.2 CABLE CONDUCTORS

16.2.1 Cables intended for supplying essential services are to have stranded conductors and to be made of electrolytic copper (see also 16.8.1.2). Table 16.2.1 specifies the minimum number of wires per conductor. Solid conductors are allowed only for mineral-insulated cables and for cables having the cross-sectional area up to 2,5 mm^2 and voltage up to 250 V, which are run through accommodation spaces.

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 the nominal diameters of any two wires in the mechanically-tightened cables conductor is not to exceed the value 1:1,3, and for conductors formed geometrically, but not tightened, 1:1,8.		

16.2.2 Connections of separate conductor wires are to be displaced from one another by not less than 500 mm along the length of the conductor.

Such connections are not to impair the mechanical and electrical properties of the wire nor to change the cross-sectional area of the wire and the conductor as a whole.

16.2.3 Separate wires of rubber-insulated copper conductors are to be tinned or coated with a suitable alloy.

Tinning or other corrosion-resistant coating of an external lay or of all wires of a rubber-insulated conductor may be unnecessary if the manufacturer takes measures to assure that the rubber insulation does not adversely affect the conductor metal.

No tinning is needed for conductors having other types of insulation.

16.3 INSULATING MATERIALS

16.3.1 Insulating materials specified in Table 16.3.1 may be used for insulation of cables and wires. The use of other insulating materials is, in each case, subject to special consideration by the Register.

Table 16.3.1

Insulation designation	Standard types of insulating materials	Permissible service temperature of a wire for calculation of permissible long-duration cable load, °C
PVC/A	Standard-type polyvinylchloride	60
PVC/D	Heat-resistant polyvinylchloride	75
EPR	Ethylene-propylene rubber	85
XLPE	Cross-linked polyethylene	85
S95	Silicon rubber	95

16.4 CABLE SHEATHING

16.4.1 Protective sheathing of cables and wires may be made of non-metal materials specified in Table 16.4.1, of lead and copper. The use of alternating sheathing materials is, in each case, subject to special consideration by the Register.

Table 16.4.1

Sheathing designation	Non-metallic protective sheathing type	Maximum permissible temperature of cable conductors, °C
SV1	Polyvinylchloride	60
SV2	Same, but heat-resistant	85
SP1	Polychloroprene rubber	85
SH1	Chlorosulfonated polyethylene	85

16.4.2 Protective sheathing is to be of uniform thickness within allowable limits, throughout the manufacturing length of a cable, and to concentrically envelop the cable conductors. The sheaths are to form an impervious covering in tight contact with the protected conductors.

16.4.3 Lead cable sheaths are to be made of relevant alloys specified by national standards.

Pure lead sheaths may only be used when the lead sheath is covered with an additional protective sheath.

16.4.4 The sheaths of electric cables and wires are, as a minimum, not to propagate combustion and not to lose in service its properties, which ensure non-propagation of combustion.

16.5 PROTECTIVE COVERINGS

16.5.1 A shielding braid is to be made of tinned copper wire. If plain copper wire is used, it is to be protected with a proper sheath. Non-shielding braids may be made of galvanized steel wire. The braid is to be uniform and its density is to be such that its mass is at least equal to 90 per cent of the mass of the same diameter tube made of the same material and having a wall thickness equal to the braiding wire diameter.

16.5.2 Metal armour is to be made of annealed and galvanized steel wire or tape wound helically, with a relevant pitch, over the cable sheath or an intermediate bedding over the sheath in such a way that a continuous cylindrical layer is formed providing protection and flexibility of the finished cable. On special demand, the armour may be made of non-magnetic metals using the above technique.

16.5.3 Cables armour or braid made of steel tape or wire is to be properly protected against corrosion.

16.5.4 Armour bedding is to be made of moisture-resistant materials.

16.6 MARKING

16.6.1 Rubber- or polyvinylchloride-insulated cables for ultimate temperatures at core over 60 °C are to be marked in a way allowing their identification.

16.6.2 Cable cores are to be marked in a way assuring adequate preservation of the marking.

In multi-core cables with cores arranged in several concentric layers, at least two adjacent cores of each layer are to be marked with different colours.

16.7 INTERNAL WIRING

16.7.1 For internal wiring of distribution boards and electric devices, solid insulated conductors are to be used (see also Table 16.3.1).

16.7.2 Non-insulated wires and busbars may be used 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 is to be made of fire-resistant and flame-retarding cables and conductors with copper cores manufactured in accordance with the requirements of the present Part or with current standards approved by the Register. The use of other cable or wire types is, in each case, subject to special consideration by the Register.

16.8.1.2 Cables and wires having stranded conductors are to be used, the cross-sectional area of the conductors being not less than:

.1 1,0 mm^2 for power supply, control and signaling circuits of essential services and for power supply circuits of other services;

.2 0,75 mm^2 for control and signaling circuits;

.3 0,5 mm^2 for instrumentation and intercommunication circuits with cables having at least four cores.

For power circuits supplying non-essential services, it is permitted to use cables with a single-wire conductor having a cross-sectional area of 1,5 mm^2 and less. The number of power cable conductors is to be consistent with a distribution circuit in phases or polarity.

16.8.1.3 In circuits with heavy inductive and capacitive loads, the use is to be made of cables designed for a working voltage approximately equal to double the rated voltage of the circuit.

16.8.1.4 The maximum permissible temperature for the insulating material of the cable core or wire used is to be at least 10 °C higher than the maximum specified ambient temperature.

16.8.1.5 In locations exposed to the action of petroleum products or other aggressive medium, the use is to be made of cables having a sheath, which is resistant to such medium. The cables not possessing such properties may be laid in such location in metallic pipes only (see 16.8.8).

16.8.1.6 In locations where cables may be subjected to mechanical damages, the use is to be made of cables having a proper armour, while the cables of other types in such locations are to be suitably protected or laid in pipes (see 16.8.8).

16.8.1.7 The cables supplying the electric drives of a sprinkler system and a fire pump from the emergency source of electrical power and running through the casings of Category A machinery spaces, galleys, drying rooms and other similar fire-hazardous spaces, are to be non-combustible or protected from exposure to flame. The above requirements also cover the remote control cables of those devices.

The cables are to be laid so as to prevent their damage due to bulkheads heating which may be caused by a fire in an adjacent space.

16.8.1.8 Cables for essential and emergency arrangements, as well as for arrangements required to be operable under fire conditions, including their feeding cables, are to be routed clear of high fire risk machinery spaces (see 16.8.1.9), except for cases when the arrangements themselves are installed in such spaces.

Where such installation of cables is necessary, the cables are to be of fire-resistant type.

16.8.1.9 The high fire risk spaces include the following:

machinery spaces of category A;

spaces, in which equipment for pretreatment of fuel and other flammable substances is installed;

galleys and their service spaces, in which cooking equipment is installed;

laundries, in which drying equipment is installed;

accommodation spaces of high fire risk;

paint rooms, store rooms and similar spaces for storage of flammable liquids;

enclosed and semi-enclosed hazardous spaces, in which explosion-proof electrical equipment is to be installed.

16.8.1.10 Cables, distribution gears, switch apparatus or protective devices, electrical accessories associated therewith are to be so designed or installed that the likehood of the device failing in case of fire in any one such space or area is minimized.

16.8.1.11 Among the arrangements required to be operable 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;

controls of watertight doors with door-position indicators and warning alarm;

emergency lighting;

command broadcasting apparatus;

low-location lighting;

remote emergency shutdown control for the systems, the operation of which may maintain spreading of fire and/or explosion.

16.8.1.12 Cables of the arrangements specified in 16.8.1.11 running through high fire risk spaces are to be fire-resistant from the control panel up to the nearest distribution panel serving the relevant area or zone.

16.8.1.13 Feeding cables of the arrangements specified in 16.8.1.10 running through high fire risk spaces are to be fire-resistant from the emergency source of power up to the nearest distribution panel serving the relevant area or zone.

16.8.1.14 Cables of devices required for operation under fire conditions including their supplying cables are to be of fire-resistant type if they pass through Category A machinery spaces, boiler rooms, galleys and other enclosed spaces of high fire risk, as well as through their casings, fire zones or decks other than those in which they are fitted. Such devices include:

general alarm system and fire detection system;

fire extinguishing systems and alarm warning of starting a fire smothering system;

fireproof door controls with door position indicators and warning signalling;

emergency lighting;

service communication and command-broadcast apparatus;

low location lighting

16.8.2 Selection of cables and wires by loads.

16.8.2.1 The calculation of permissible current loads is to be carried out basing on the standards or calculation methods approved by the Register. Continuous permissible current loads for single-core cables and wires with different insulating materials at the ambient temperature of 45 °C are to comply with the values specified in Table 16.8.2.1.

The current loads given in this Table applies to the following cases of cable laying:

.1 for laying not more than 6 cables in one bunch or in one row fitted tightly together;

.2 for laying cables in two rows irrespective of the number of cables in one row subject to a free space for air circulation is provided between each group or bunch of 6 cables.

Where more than six cables, which may simultaneously be under rated current, are laid in a bunch or where no free space for air circulation between the cables is provided, the permissible current loads for the given cross-section specified in Table are to be reduced by 15 per cent (factor 0,85).

16.8.2.2 The values of rated current loads in amperes for the cross-sections in Table 16.8.2.1, and also for any cross-section are calculated by the formula

$$I = \alpha S^{0,625} \qquad (16.8.2.2)$$

where α = factor corresponding to the maximum permissible working temperature of the conductor according to Table 16.8.2.2;

S = nominal cross-sectional area of the conductor, mm^2.

16.8.2.3 The permissible current loads for double-, three- and four-core cables are to be determined by reducing the values given in Table 16.8.2.1 for the given cross-section using the following correction factors:

0,85 for double-core cables;

0,70 for three- and four-core cables.

16.8.2.4 The permissible current loads of cables

Table 16.8.2.1

Nominal cross sectional area of conductor, mm^2	Insulating material				
	Polyvinylchloride	Heat-resistant polyvinylchloride	Butyl rubber	Ethylene-propylene rubber, cross-linked polyethylene	Silicon rubber or mineral insulation
	Maximum working permissible temperature of conductor, °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	—

Table 16.8.2.2

Maximum permissible temperature of conductor, °C	Factor α for nominal cross-sectional area S, mm^2	
	⩾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	18	20

16.8.2.4 The permissible current loads of cables and wires in circuits with an intermittent or short-time load are to be determined by multiplying the continuous cable loads specified in Table 16.8.2.1 or selected according to Table 16.8.2.2 by the correction factors given in Table 16.8.2.4.

16.8.2.5 The permissible current loads specified in Table 16.8.2.1 are given for an ambient temperature of 45 °C. The correction factors for conversion of the permissible loads to be used depending on the ambient temperature are given in Table 16.8.2.5.

16.8.2.6 Selecting the cables for final branch circuits of lighting and cooking appliances, correction or simultaneity factors are not to be used.

16.8.2.7 The cables are to be so designed that they could withstand the maximum short-circuit current with due regard to current and time ratings of protective devices and to the peak value of the prospective short-circuit current of the first one-half period.

16.8.2.8 The cables laid in parallel for the same phase or pole are to be of the same type, laid together and to have the same cross-sectional area of at least 10 mm^2 and the same length.

16.8.3 Selection of cables cross-sectional area for permissible voltage drop.

16.8.3.1 Voltage drop on the cable connecting generators to the main and emergency switchboard is not to exceed 1 per cent.

Table 16.8.2.4

Correction factor for cables and wires with or without metallic sheathing

Nominal cross-section of conductor, mm^2	Intermittent mode, cyclic duration factor 40 per cent		Short-time operation, 30 min		Short-time operation, 60 min	
	Cables and wires					
	with metallic sheathing	without metallic sheathing	with metallic sheathing	without metallic sheathing	with metallic sheathing	without metallic sheathing
1,09	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	1,07	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

16.8.3.2 Voltage drop between the busbars of the main or emergency switchboard and any points of the installation under normal operational conditions is not to exceed 6 per cent of the rated voltage, and for services supplied from an accumulator battery with the rated voltage up to 50 V, this value may be increased up to 10 per cent. For transient processes, e.g. when electric motors are started, the short-time voltage drop in excess of 10 per cent may be permitted.

For navigation lights circuits, it may be required to limit the voltage drop by a lesser value in order to ensure necessary luminous intensity.

Table 16.8.2.5

Ultimate conductor 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

16.8.3.3 The cables feeding directly-started alternating-current electric motors are to be computed in such a way that the voltage drop on motor terminals at starting does not exceed 25 per cent of the rated voltage.

The possibility of raising the above voltage drop is, in each case, subject to special consideration by the Register.

16.8.4 Cable laying.

16.8.4.1 Cables are to be laid in runs which are, as practicable, to be straight and accessible to prevent their twisting and other mechanical effects that may cause their damage. The cable runs are to pass through locations where the cables are not subjected to long exposure to lubricating oil, fuel oil, water and excessive external heating. The cable runs are to be at least 100 mm away from heat sources.

16.8.4.2 No cables are to be laid within 50 mm from the double bottom and petroleum product tanks.

The cables are to be at least 20 mm away from the shell plating, as well as from fireproof, watertight and gastight bulkheads and decks.

16.8.4.3 Where cable bunches not tested for flame spreading are laid, the following measures are to be taken:

.1 fire-retarding divisions are to be used, B-0 class at least (see also 2.1.29, Part VI "Fire Protection" of MODU/FOP Rules), where the bunches enter the main and emergency switchboards, central control panels and consoles for the powerplant and essential machinery, and also at each end of fully enclosed cable runs (see Fig. 16.8.4.3.1);

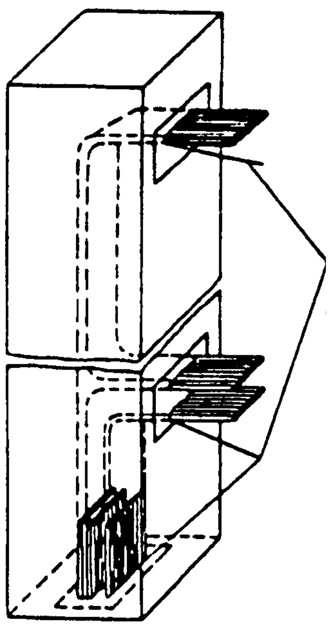


Fig. 16.8.4.3.1
Fully enclosed cable run protection with B-0 fire-retarding division

.2 in enclosed and semi-enclosed spaces and locations, cable bunches laid in partly enclosed and open cable runs are to be protected with:

a fire-resistant coating over the entire length of vertical cable runs and over a length of 1 m every 14 m apart for horizontal cable runs (see Fig. 16.8.4.3.2-1);

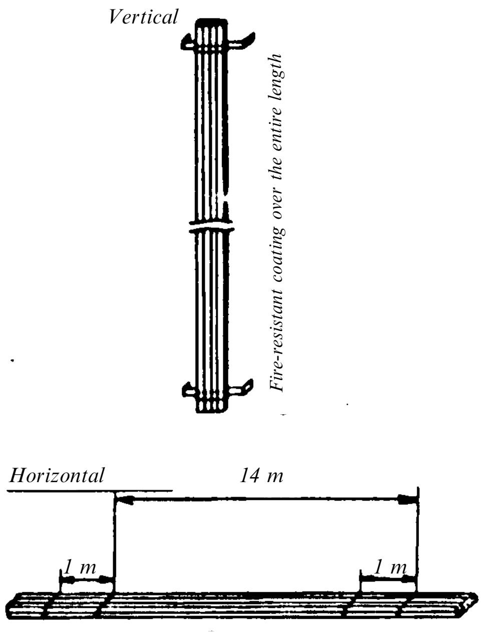


Fig. 16.8.4.3.2-1
Cable run protection with fire-resistant coating

B-0 fire-retarding Class divisions at least on every second deck or every 6 m apart for vertical cable runs, and every 14 m apart for horizontal cable runs (see Fig. 16.8.4.3.2-2). Fire-retarding divisions are to be made of steel plates at least 3 mm thick and dimensioned as shown in Fig. 16.8.4.3.2-2.

16.8.4.4 Cables having external metallic sheaths may be laid on structures of light metal or fastened with staples of light metal only when reliable corrosion protection is provided.

16.8.4.5 Cable laying under the flooring of machinery spaces in the ordinary way is not allowed. Where such laying is necessary, cables are to be enclosed in metallic pipes or conduits (see 16.8.8).

16.8.4.6 Cables laid across expansion joints of hull structures are to have expansion loops of a radius adequate for such joint. The inside diameter of the loop is to be not less than 12 outside diameters of the cable.

16.8.4.7 Laying of cables with insulation designed for different permissible temperatures in common cable runs is to be effected in such a way that the cables are not heated above the permissible tempera-

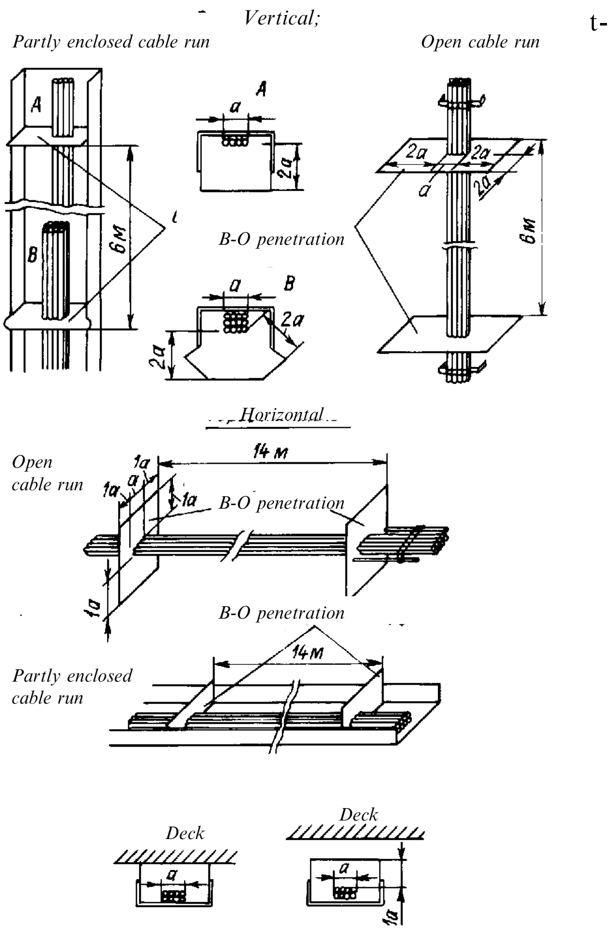


Fig. 16.8.4.3.2-2
Cable runs protection with B-0 fire-retarding divisions

ure of the cables having a lesser permissible temperature.

16.8.4.8 Cables with different protective coverings the less durable of which may be damaged, are not to be laid in one common pipe, conduit or by the other way of joint not supported laying.

16.8.4.9 Cores of multi-core cables are not to be used for supply and control of essential services not associated with one another.

The multi-core cables are not to be used simultaneously for a safety voltage and working ones exceeding the safety level.

16.8.4.10 Where services are supplied with two separate feeders, these feeders are to be laid in different runs as far apart as practicable in the horizontal and vertical directions.

16.8.4.11 Where cables are laid in ducts or other structures made of combustible materials, the locations of cable laying are to be protected against ignition with fire-protective means like lining, coating or impregnation.

16.8.4.12 The laid cables are not to be flushed into thermal or sound insulation if it is made of combustible materials. The cables are to be separated from such insulation with the non-combustible material lining or laid at a distance of at least 20 mm from it.

Where cables are laid in thermal or sound insulation made of non-combustible materials, the cables are to be designed for the relevant reduction of loading.

16.8.4.13 Cables laid in refrigerated spaces are to have the protective sheath of metal, polychloroprene rubber or other material resistant to the exposure to a coolant.

Where cables are provided with armour, the last is properly to be protected against corrosion.

16.8.4.14 Cables in refrigerated spaces are to be laid on perforated panels or bridges and fastened so as to provide a free space between the cables and space walls. The panels, bridges and cable clips are to be protected against corrosion.

Where cables cross the thermal insulation of a refrigerated space, they are to pass through it at a right angle in a suitable grommet sealed at both sides.

16.8.4.15 For cable laying, minimum internal bending radii are to be maintained in accordance with Table 16.8.4.15.

Table 16.8.4.15

Cable type		External cable diameter, mm	Minimum bending radius of cable
Cable insulation material	Type of protective cable covering		
Rubber or polyvinylchloride	Armoured with metal tape or wire	Any	10d
	Metal sheath	Any	6d
	Lead alloy and armour	Any	6d
	Other coverings	Under 9,5	3d
		9,5 to 25,4	4d
		Over 25,4	6d
Varnished cambric	Any	Any	8d
Mineral insulation	Metal	Under 7,0	2d
Ethylene-propylene rubber or cross-linked polyethylene	Semi-conducting and/or metal	7,0 to 12,7	3d
		Over 12,7	4d
		25 and over	10d

16.8.4.16 Cables and earthing jumpers of the equipment mounted on shock absorbers are to be terminated so as to prevent their damage in service.

16.8.4.17 Cables laid on open decks, masts and the like are to be protected against the direct exposure to sun radiation.

16.8.5 Cable fastening.

16.8.5.1 Cables are to be properly fastened with clips, staples, holders and the like made of metal, or non-combustible or flame-retardant material.

The fastener surface is to be wide enough and have no sharp edges. The fasteners are to be selected in such a way that the cables are securely fastened without damage to their protective coverings.

16.8.5.2 When cables are laid horizontally, fastener spacings are not to exceed the values given in Table 16.8.5.2, and for vertical cable runs, they may be increased by 25 per cent.

Table 16.8.5.2

External cable diameter, mm		Spacing between fastening pints for cables, mm		
Over	Under	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 are to be fastened so that mechanical strains in cables are not transmitted to their inlets and connections.

16.8.5.4 Cable runs and cables laid in parallel with the MODU or FOP shell plating are to be fastened to framing rather than to plating.

On watertight bulkheads and masts, cables are to be fastened on special structures (saddles, tray plates, chocks and the like).

16.8.5.5 Cables running parallel to bulkheads subjected to sweating are to be laid on bridges or perforated panels so as to provide a space between the cables and bulkheads.

16.8.5.6 Cable runs are to be laid with a minimum number of crossings. Bridges are to be used where cables cross each other. An air gap of not less than 5 mm is to be left between the bridge and the cable run crossing it over.

16.8.6 Cables penetrating decks and bulkheads.

16.8.6.1 Cable penetrations through watertight, gastight and fire-resisting bulkheads and decks are to be sealed with appropriate devices.

Sealing where the cables penetrate through the above bulkheads and decks are not to impair their tightness; no forces resulting from elastic hull deformation are to be transmitted to the cables.

16.8.6.2 Where cables are laid through non-tight bulkheads or structural elements less than 6 mm thick, holes for cables penetration are to be fitted with linings and bushes to prevent damages to the cables.

No linings or bushes are needed for bulkheads or framing 6 mm and over thick, but hole edges are to be rounded.

16.8.6.3 Cable laying through watertight decks is to be effected by one of the following ways:

.1 in metal pipes (risers) extended above the deck to a height not less than 900 mm in locations of potential mechanical damage to the cable, and to a height not less than that of the door coaming in the space where such damage is unexpected;

.2 in common metal sockets or boxes with additional protection of cables with casings of the height specified in 16.8.6.3.2.

The boxes are to be filled with packing compound, while the pipes are to be fitted with glands or packed with cable compound.

16.8.7 Packing compounds.

16.8.7.1 In order to fill the cable boxes in watertight bulkheads and decks, the use is to be made of packing compounds having good adhesion to the inside surfaces of cable boxes and cable sheaths, being resistant to water and petroleum products, not shrinking and not losing 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 are to withstand the standard fire test specified for the given class of division in 2.1.2.6, Part VI "Fire Protection" of Rules for the Classification and Construction of Sea-Going Ships.

16.8.8 Cable laying in pipes and conduits.

16.8.8.1 Metal pipes and conduits for cable laying are to be protected against corrosion on the inside and outside surfaces. The inside surface of pipes and conduits is to be even and smooth. Pipe and conduit ends are to be machined or protected so as to prevent their damage when cables are drawn in.

Cables with lead sheaths not having any additional protective covering are not to be laid in pipes and conduits.

16.8.8.2 The bending radius of a pipe and conduit is to be not less than that permissible for the largest diameter cable laid in them (see 16.8.4.15).

16.8.8.3 The total cross-sectional area of all cables determined from their external diameters is not to exceed 40 per cent of the inside cross-sectional area of the pipe and conduit.

16.8.8.4 Pipes and conduits are to be mechanically and electrically continuous and securely earthed unless this earthing has not been effected while mounting the pipes and conduits.

16.8.8.5 Pipes and conduits are to be installed so as to prevent accumulation of water therein. Where needed, ventilation holes are to be provided, as far as possible, in the highest and lowest points of the pipes and conduits so as to ensure air circulation and to prevent vapour condensation. The holes are permissible only in places where it will not enhance the danger of explosion or fire.

16.8.8.6 Cable pipes and conduits installed along the unit's hull and which can be damaged due to the hull deformation are to be fitted with compensating devices.

16.8.8.7 Where the use of cables with combustible covering is allowed according to 16.8.1.1, these cables are to be laid in metallic pipes.

16.8.8.8 Cables laid vertically in pipes and conduits are to be fastened so as to prevent their damage under the tension caused by their own mass.

16.8.9 Special precautions for single-core cables for alternating current wiring.

16.8.9.1 The use of single-core cables for alternating-current wiring is not recommended. Where it is needed, the cables for circuits rated in excess of 20 A are to meet the following requirements:

.1 the cables are not to have coverings of magnetic material;

.2 the cables of one circuit are to be laid in one cable run or in one pipe. Laying of such cables in different pipes is allowed only when non-magnetic material pipes are used;

.3 cable clamps, unless they are made of non-magnetic material, are to include all the single-core cables of one circuit;

.4 the spacing between the cables is to be not more than one cable diameter.

16.8.9.2 The cables of one circuit are to be laid in one cable run or in one metallic pipe and to be as short as practicable. It is allowed to lay such cables each under its non-magnetic screen (in a pipe) earthed at one point and isolated from other cable screens and from the hull.

16.8.9.3 Where single-core cables having a current rating over 250 A are laid parallel to steel structures, the spacing between the cables and these structures is to be not less than 50 mm.

16.8.9.4 Where single-core cables of a cross-sectional area over 185 mm^2 are laid, the cables are to be crossed at intervals of not more than 15 m. Crossing is of no need for cables under 30 m long.

16.8.9.5 Multicore cables with conductors in parallel are to be laid as single-core ones and all the requirements for single-core cables apply in this case.

16.8.10 Connection and tapping of cables.

16.8.10.1 The ends of rubber-insulated cables brought in machines, apparatus, switchgear and other equipment are to have contact, protective and sealing terminations which ensure a reliable electrical contact, prevent the penetration of moisture inside the cable, and also protect the insulation of cable cores against mechanical damage and effects of air and oil vapours.

16.8.10.2 Where rubber-insulated cable cores are connected, provision is to be made for insulation protection against damage (wear, etc.). Cable terminations and cable core connections are to be made so as to retain their electrical, mechanical and other characteristics after mounting and in service.

16.8.10.3 The protective covering of a cable inserted into a device is to enter not less than 10 mm inside.

16.8.10.4 Connection of cables where they are tapped is to be effected in branch boxes using standard clamps.

16.8.10.5 Where additional connections during cable laying are needed, they are to be effected in suitable junction boxes provided with clamps. The joint as a whole is to be protected against ambient conditions. The applicability of cable joints and of other methods of cable connections, except for the above-specified, is, in each case, subject to the special consideration by the Register.

17 ELECTRIC PROPULSION PLANTS OF SELF-PROPELLED MODU

17.1 GENERAL

17.1.1 The electrical equipment of the electric propulsion plant is to meet the requirements of other sections and chapters of this Part of the Rules unless otherwise specified in this Section.

17.1.2 The rated torque in reverse developed by the propulsion motor is to bring the MODU to rest from the maximum ahead speed within the time agreed between the MODU builder and the electric propulsion plant manufacturer basing on the design characteristics of propellers during reverse and other appropriate parameters of power electrical equipment of the propulsion plant.

17.1.3 For alternating current propulsion plants, provision is to be made for an appropriate torque margin calculated according to the propeller characteristics and the MODU mass and hydrodynamic characteristics. This margin is to ensure a propulsion motor non-drop out of synchronism in navigational storm conditions and, for multi-propeller plants, while manoeuvring.

17.1.4 Designing an electric propulsion plant, provision is to be made for the relevant measures to avoid excessive torsional vibrations and the vibration both of the system "propeller — propulsion motor" and of the system "generator — prime mover". In this case, it is to be taken into account not only the characteristics of gyrating masses, but the electrical characteristics of the system as well.

17.1.5 Propulsion generators may be used for supplying industrial or auxiliary electrical machinery and arrangements provided voltage and frequency stability can be assured under all running conditions, including those of manoeuvring, in accordance with the requirements of 2.1.3. In this case, a system of priorities for consumers supplied from the propulsion generators which provides for a relevant sequence of their starting and operation procedures is to be established.

17.1.6 It is recommended to provide electrical heating in the locations of electrical machinery, switchboards and control panels of the electric propulsion plant.

17.1.7 Stationary lighting is to be provided underneath the generators and motors of the electric propulsion plant.

17.1.8 In electrical systems of electric propulsion plants, the voltage levels not in excess of those specified in 4.1 and 18.2.2 are permitted.

17.2 PRIME MOVERS OF ELECTRIC PROPULSION PLANT

17.2.1 Prime movers of any type of the electric propulsion plant are to be fitted with speed regulators which are capable of maintaining the preset rotational speed with deviations not exceeding 5 per cent of the rated one within the range from the full load to idle running. Where the propeller speed control is associated with the control of the prime mover speed of the electric propulsion plant, the prime mover regulator is to be provided with devices both for the local and remote setting of the relevant speeds.

17.2.2 When generators run in parallel, a regulating system is to ensure the steady operation of an electric generating system (electric propulsion plant) within the whole range of prime movers speeds and outputs.

17.2.3 The output of prime movers with due regard to their static and dynamic overloading characteristics is to be consistent with (adequate to) the electric power needed in transient processes under the conditions when the electrical equipment operates in a manoeuvring mode and under severe storm conditions.

17.2.4 In case of a crash stop when the MODU is at full ahead speed and regarding its large inertia, the prime movers of the electric propulsion plant are to be capable of absorbing recuperation energy without the activation of the protection against excessive rotational speed. The excessive rotational speed setting of the protection device is to comply with the characteristics agreed by the mechanical and electrical equipment manufacturers. In order to absorb excessive recuperation energy, provision is to be made for external devices, like virtual or dynamic braking resistors, or other ballast receivers of electrical power. The recuperated energy may also be limited by the control system.

17.3 ELECTRIC MACHINES

17.3.1 Cooling and ventilation.

17.3.1.1 The generators and electric motors of an electric propulsion plant, which have a closed-circuit ventilation, are to be fitted with thermometers for measuring the temperature of outgoing air and water. The temperature condition of electric machines is to be within the limits set by their manufacturers under all running conditions, including the full load, at the full excitation and the maximum ambient temperature.

17.3.1.2 It is recommended to provide closed-circuit ventilation systems with devices to monitor air humidity, and also with a visual and audible alarm activated at the cooling air temperature rise above the set level.

17.3.1.3 In the electric machines having a closed-circuit cooling system with heat exchangers, provision is to be made for a visual and audible alarm at the temperature rise above the set level and at the flow loss both in the primary and secondary cooling medium circuits of generators and electric motors of an electric propulsion plant.

17.3.1.4 Air-cooled propulsion motors are to be fitted with duplicated fans of a forced ventilation. Each fan is to have a capacity sufficient to ensure normal conditions of motor operation.

Provision is to be made for a visual alarm to indicate fans operation and for an audible alarm of their stopping.

17.3.1.5 The part of electric propulsion machines (motors and generators) below the flooring is to be structurally protected against ingress of water and other hostile media into the machine. Where the machines are located in a dry compartment or protected against water ingress with a watertight foundation and if, in addition, an alarm activated at water ingress into that compartment is provided, the additional protection of the machine housing is not needed.

17.3.1.6 The generators and electric motors of an electric propulsion plant are to be fitted with filters for cleaning a cooling air in open- and closed-circuit ventilation systems. Ventilation ducts are to be designed so as to prevent water ingress into the machine.

17.3.1.7 Liquid-cooled electric machines are to be designed so as to prevent potential sea water ingress on their windings, and are to be provided with devices for monitoring cooling systems operation.

17.3.1.8 In multi-armature machines, a self-contained liquid-cooled system is to be provided for each armature.

17.3.1.9 Stator windings of alternating current machines and pole windings of direct current machines rated at 500 kW and over are to be provided with built-in temperature sensors.

17.3.1.10 In order to prevent accumulation of vapours and a condensate in electric machine housings, preheaters are to be provided.

17.3.2 Bearings and their lubrication.

17.3.2.1 A circulating forced-feed oil system for bearings of machines of an electric propulsion plant is to be fitted with two lubricating oil pumps, each with a capacity sufficient to ensure normal operation of the plant under all conditions from the minimum loading and rotational speed up to overload conditions irrespective of going ahead or astern.

17.3.2.2 Where a circulating lubrication of bearings is used, the oil system of an electric propulsion motor is to be fitted with a filter and a gravity feed tank to ensure oil supply to the bearings within at least 15 min with the pump stopped unless the bearings design provides for normal lubrication during the propulsion motor running-down.

17.3.2.3 A circulating lubrication system is to be provided with an audible and visual alarm activated in the event of a pressure fall in the oil system, and also with means for measuring the oil temperature at the outlet.

17.3.2.4 Propeller shafts and bearings are not to sustain damage due to low rotational speeds irrespective of whether it occurs when power is applied to a propulsion motor or rotation is initiated by a propeller, and under the worst temperature conditions of lubrication.

17.3.3 Machines excitation.

17.3.3.1 An excitation system of machines of an electric propulsion plant is to be supplied from at least two converters of electrical power and if one of these fails, the others are to ensure the full demand for electrical power for excitation even at an increased load needed for manoeuvring, and also at short circuits, for reliable disconnection of short-circuit currents with switching and protective gear.

It is allowed to supply the excitation system of machines of an electric propulsion plant from the main switchboard busbars provided they are supplied under all conditions in accordance with the above requirements.

17.3.3.2 Excitation systems of direct current propulsion motors and generators are to be so designed that in case of the loss of excitation at the electric propulsion motor, the field current is immediately removed to zero from the generators.

This requirement may be dispensed with where direct-current systems with constant current or voltage having two or more electric motors are used, and also where special excitation systems are applied which make it unnecessary.

17.3.3.3 Field circuits are to include devices for killing magnetic field energy when field windings are disconnected (see 5.4.3).

17.3.3.4 Excitation and automatic control systems are to be designed so that electric propulsion motors may be protected against overspeeding when the propeller is broken down or working clear of water.

For constant current systems, this requirement is to cover all the electric motors of the constant-current circuit.

17.3.3.5 Where the exciters of electric propulsion machines are used for supplying other machinery and arrangements, an interlocking is to be provided to prevent the use of this power supply during the propulsion plant operation, or a notice is to be placed in an appropriate location warning that this power supply may be used only when the propulsion plant does not operate. This requirement does not concern a stand-by exciter.

17.3.3.6 For constant current systems, provision is to be made for protection, which ensures removal of a field current from generators and electric motors when the main current circuit is broken.

17.3.3.7 Alternating current machines are to withstand without damage electrodynamic and thermal effects of short-circuit currents across their terminals at rated original parameters within 2 s as specified in 10.1.2.

17.3.3.8 Electric propulsion machine rotors are to withstand without damage an elevated rotational speed not less than specified in 10.1.4.3.

17.3.4 Access for maintenance and repair.

17.3.4.1 In order to provide a possibility to monitor condition and to effect repair, provision is to be made for unobstructed access to stator and rotor windings, and also access to pole coils for their dismantling and replacement.

17.3.4.2 In order to provide a possibility to monitor and replace bearings, provision is to be made for an arrangement for support (suspension) of an electric machine shaft.

17.3.4.3 The relevant access is to be provided for the working of collector and contact ring surfaces, and also for the replacement and grinding of brushes.

Slip clutches are to be so designed that they may be dismounted without disassembly (as a unit) and the axial shift of the drive and driven shafts and without dismantling of poles.

17.4 MAIN CIRCUITS AND FIELD AND CONTROL CIRCUITS

17.4.1 No overload protection devices and circuit breakers are to be installed in field circuits excepting those which control machines excitation at short circuits or failures in the main current circuit only.

17.4.2 Where the definite sequence of switching operations is to be assured, provision is to be made for a reliable interlock to prevent wrong switchings.

17.4.3 Switches for selecting the modes of operation in electric propulsion plant circuits, while these are de-energized, are to have an interlocking device to prevent their opening, while alive, or closing by mistake.

17.4.4 Generators and electric motors of constant-current systems are to be connected or disconnected when the field current is removed from these machines without breaking the main current circuit.

17.4.5 The systems of electric propulsion plants which include two or more generators, two or more semiconductor converters, or two or more propulsion motors operating on one propeller shaft, are to be so designed that any separate set may be switched out of use and electrically disconnected.

17.4.6 Where a propulsion plant comprising only one generator and one propulsion motor can not electrically be connected to another propulsion plant, each machine is to be provided with more than one exciter. This requirement does not cover self-excited generators and multi-propeller propulsion plants in which one additional (stand-by) exciter set may be common for the entire plant.

17.4.7 Each exciter set is to be supplied from the main switchboard by a separate feeder. Field winding circuits are to be provided with means to kill voltage bursts at their disconnection.

17.4.8 In direct current "generator — motor" propulsion plants, the field system of generators is to be so designed that when the field circuit of the propulsion motor is switched off (with a contactor or breaker), at once the excitation of the generator is removed and its voltage is immediately stepped down to zero.

17.4.9 In constant voltage systems having two or more independently-controlled propulsion motors supplied from one or more generators running in parallel, in the event of loss of excitation by one of the motors, its armature (the main current circuit) is immediately to be disconnected with a circuit breaker so that the remaining serviceable motor could continue operation.

17.4.10 Where semiconductor exciter sets, in which diodes and thyristors are installed for protection against overvoltages in field coils, are used, or when they are used as freewheeling diodes, the activation of semiconductor fuses is not to result in the opening of a field circuit.

17.4.11 The activation of the fuses installed for protection of field circuits is not to cause the opening of circuits of discharging resistors for field coils.

17.4.12 Where the generators of the MODU main source of electrical power are also used as part of the electric propulsion plant, other than of the booster (auxiliary) plant, they are to meet the requirements of this Section as well.

17.4.13 Any malfunction of a control signal in the propulsion plant including malfunctions of feedback sensors, or of cable runs between a control station and final control devices of a system, is not to result in propeller speed increase above the set level.

17.5 CONTROL STATIONS OF ELECTRIC PROPULSION PLANTS

17.5.1 The main control station located in the machinery or special space is to be provided for each electric propulsion plant.

It is allowed to arrange additional remote control stations located in places from which the unit is controlled.

17.5.2 Where the control from the panel or desk of an electric propulsion plant involves the use of an electric, pneumatic or hydraulic drive, the failure of this drive is not to result in the disconnection of the plant, and each of the control stations on the panel or desk is immediately to be ready for manual operation.

17.5.3 Where several control stations of an electric propulsion plant are available, the switch of the stations is to be provided in the main control station. Such a switch is to ensure the activation of only one any control station. In this case, all the stations are to be provided with indication of the station from which control is effected. Where the mismatched position of handles may result in the failure of the control system or propulsion plant sets, the transition from one control station to another is to be feasible only with the matched position of control handles. The above does not apply to the systems in which control handles are electrically or mechanically connected so that they are matched at all times.

17.5.4 The control stations at the main control station or in the machinery space are to prevail over other control stations, e.g. over the bridge control station. The last or other remote control station is to be also fitted with an engine telegraph for command transmission to the control station in the machinery space or main control station.

17.5.5 The control stations of electric propulsion plants are to meet the requirements of Part VII "Machinery Installations and Machinery" of MODU/FOP Rules.

17.5.6 The remote control system is to be so designed that the control may be effected from the machinery space or main control station when the equipment located outside the machinery space fails.

17.5.7 The remote control system of an electric propulsion plant is to be so designed that no time delay is needed for the personnel when manipulating a control handle at the control station located in the wheelhouse (on the bridge).

17.5.8 All the equipment for the control of prime movers, power switches, contactors, switches of machines field system and the like are to be mutually interlocked so as to prevent its improper operation. Provision is also to be made for interlocking to prevent the potential operation of the plant with the shaft-turning gear engaged.

17.5.9 Each control station is to be provided with the device, which is independent of the handle for regular control, for the urgent stop of the propeller. The start of the propulsion plant is to be feasible only when the control handle is in the zero position and the plant is ready for operation what is to be indicated with a visual signal at control stations.

17.5.10 The electric propulsion plant is to be provided with a manual local or emergency control system and in doing so all controls, switches, field regulators and controllers are to be handled without operator's excessive efforts.

17.5.11 The doors of switchboards and control system cabinets are to be fitted with locks to prevent access to them when they are alive. Special keys available for the competent personnel only are to be provided.

17.5.12 Each control station is to be provided with a visual signal indicating the existence of voltage in control circuits and with the instruments specified in 17.8.

17.6 ELECTRIC PROPULSION PLANTS WITH SEMICONDUCTOR CONVERTERS

17.6.1 General.

17.6.1.1 The power of electric power sources and services connected to the electric propulsion plant busbars is to be determined with due regard for the prospective distortions arising on these busbars as well as for the additional distortions resulting from the asymmetry of the main circuit currents and voltages in the transient conditions of the electric propulsion plant operation.

17.6.1.2 Main generators, semiconductor converters of electric propulsion motors, as well as the apparatus of main current circuits are to withstand an overcurrent of at least 250 per cent of I_{nom} within two seconds (see also 10.1.2).

17.6.1.3 The power of electric propulsion motors is to be determined with due regard for prospective voltage distortions at the semiconductor converter outlet.

17.6.1.4 The main generators and electric propulsion motors are to ensure the specified technical parameters (thrust value, reverse rate, etc.) in accordance with the propulsion plant purpose, under voltage and current distortions caused by semiconductor converters operation.

17.6.1.5 The overload capacity of main generators and electric propulsion motors is to meet the operational requirements. If needed, measures are to be taken to compensate for the reduction of the overload capacity due to the presence of higher voltage harmonics in the operation of semiconductor converters.

17.6.1.6 The power condensers of filters used in semiconductor converters for distortion factor improve are to be provided with discharging devices.

17.6.1.7 Where semiconductor converters are fitted with a forced cooling system, the operation of this system is to be monitored by an alarm system. In addition to the alarm system, when the cooling system fails, provision is to be made for the automatic reduction of the load (current) of power semiconductor elements. The signal of the alarm system is to be generated with the sensors of cooling medium flow, the alarm on fans supply loss or with the sensors of the diodes and thyristors temperature.

17.6.1.8 Converters are to be so designed and installed that their elements are readily accessible for prompt repair or replacement.

17.6.1.9 In case of a common electric-generating plant or power take-off from the electric propulsion plant busbars, unless the value of the non-linear distortion factor of power supply voltage complies with 2.2.1.3, the MODU services switchboard is to be supplied through special transformers or filters.

17.6.2 A.C./D.C. electric propulsion plants.

17.6.2.1 For the electric propulsion motors supplied by a rectified current, the current pulsation factor is determined by the following formula

$$K_p = \sqrt{\Sigma I_v^2} / I_{dH} \qquad (17.6.2.1)$$

where v = harmonic number;
I_{dH} = constant component of a rectified current;
I_v = effective value of the v-th harmonic current.

For the electric propulsion motors supplied by D. C. generators, the current pulsation factor is not to exceed 2 per cent.

17.6.2.2 Dynamic braking current is not to exceed 200 per cent of I_{nom}.

17.6.3 A.C./A.C. electric propulsion plants.

17.6.3.1 The power of the main generators is to be determined with due regard for the prospective asymmetrical loading of phases as a result of using semiconductor converters of A.C./A.C. frequency (without a D.C. link).

17.7 PROTECTION OF ELECTRIC PROPULSION PLANTS

17.7.1 Electric propulsion plant systems are to have protection against ironwork fault. The protective device is to be so designed that the leakage current does not exceed 20 A.

17.7.2 It is not allowed to use safety fuses as an overload protection device in the main and field circuits of the electric propulsion machinery (see also 8.2.9).

17.7.3 Where the direct current generators of electric propulsion plants are connected in series, provision is to be made for protective devices to prevent the reverse of the generating set in case of the partial or complete loss of torque by the prime mover.

17.7.4 Arrangements are to be made to limit or absorb the power generated by the electric propulsion motor under transient conditions or during the propeller reverse, if this power is likely to cause overspeeding of the generator prime movers.

Speed increase of the generator prime movers being part of the electric propulsion plant is not to exceed the values specified in Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships.

17.7.5 The electric propulsion plant is to have no-voltage protection. Self-starting after the activation of any protection without its manual resetting is to be ruled out.

17.7.6 Electric propulsion plants are to be provided with short-circuit overcurrent protection and with overload protection. The activation of the overload protection is to be preceded by the actuation of an audible and visual alarm. The overload protection is to be so set that it could not be activated in short-time overloads caused during normal manoeuvring or while underway in storm conditions, or when navigating in broken ice.

The overload protection is to have a disconnecting device used when necessary.

17.7.7 D.C. propulsion plants are to be provided with protection against excessive propeller overspeed which may be the result, for instance, of abrupt load reduction when the propeller is working clear of water or lost.

17.7.8 The semiconductor converters in the main and field circuits of generators and motors of an electric propulsion plant are to be provided with the following kinds of protection against:

.1 external and internal short-circuits and overloads;

.2 overvoltages;

.3 change of inverter state where the converter is to operate in the inverter mode;

.4 de-energizing of a control circuit.

When the fuses in these circuits are activated, a signal is to be given in the alarm system.

17.7.9 The disconnection of a semiconductor converter or its components is not to result in impermissible overloads and overvoltages in the electric propulsion plant system.

17.7.10 Provisions are to be made for devices for the selective disconnection or speedy reduction of magnetic fluxes of the main generators and propulsion motors when an overload current in the main circuit reaches the values which are dangerous for the electric machines.

17.7.11 The protection system is to be independent for each circuit which includes an electric propulsion motor and a semiconductor converter.

17.8 MEASURING INSTRUMENTS AND ALARMS

17.8.1 Provisions are to be made for at least the following measuring instruments to ensure monitoring of the system parameters affecting the operation of a direct current propulsion plant:

.1 an ammeter in the main current circuit for each generator;

.2 a voltmeter in the main current circuit for each generator;

.3 an ammeter in the field circuit for adjustable excitation systems and in the propulsion motor field circuit;

.4 a voltmeter in the field circuit for adjustable excitation systems;

.5 a tachometer for electric propulsion motors or propeller shafts.

Additional requirements for A.C. systems:

.6 a frequency indicator;

.7 a synchronizer for generators paralleling;

.8 a wattmeter.

17.8.2 Depending on the system design and an individual set power, it is to be provided:

.1 for propulsion plant generators rated at 500 kW and over per set:

a system for measuring the temperature of stator windings;

.2 for propulsion motors supplied from the main switchboard:

an ammeter for the armature current of each motor;

.3 for propulsion motors supplied from semiconductor converters:

an ammeter for the armature current of each motor;

a voltmeter for voltage applied to each armature;

an ammeter at the input of each circuit of the parallel rectifier bridge of the converter;

.4 for propulsion motors rated at 500 kW and over:

an alarm system warning of the high temperature of windings;

.5 for each variable-speed propeller shaft:

a tachometer at each control station.

17.8.3 Where a propulsion plant is controlled from the control station outside the machinery space, this station is to be fitted with all inherent instruments providing adequate information on the parameters of electric propulsion plant operation.

17.8.4 The control stations of an electric propulsion plant are to be fitted, as a minimum, with the following indicators for each propeller:

"Ready to operate",

"Fault",

"Limited power" — for cases of faults, e.g. in the cooling system of the motor, converter or when the generators loading is limited.

Each control station is to be provided with a visual alarm to indicate the presence of voltage in control circuits.

17.8.5 The electric propulsion plant system is to be provided with an instrument to check insulation resistance.

Provision is to be made for monitoring insulation resistance in the main current circuits, and also for a visual and audible alarm activated when the insulation resistance falls below the set limits.

This requirement is not applicable to electrical energy distribution systems with the neutral point earthed to the hull which are fitted with the devices for protection against ironwork fault.

17.9 CABLES AND WIRES OF ELECTRIC PROPULSION PLANT

17.9.1 The conductors of cables terminated at external blocks and devices of an electric propulsion plant, excepting computer network cables, the conductors of cables of monitoring systems or other automation equipment operating at very weak working currents are to consist of at least seven wires per strand and to have a cross-sectional area of at least 1,5 mm^2.

17.9.2 Mechanical strength and insulation quality, as well as the other characteristics of all the cables of an electric propulsion plant are to meet the requirements of Section 16.

17.9.3 The main current cables of electric propulsion plants are to be laid at a distance of at least 0,5 m away from lower voltage cables or cables for other purposes.

18 REQUIREMENTS FOR ELECTRICAL EQUIPMENT DESIGNED FOR VOLTAGES ABOVE 1 KV UP TO 15 KV

18.1 GENERAL

18.1.1 Scope of application.

The following requirements apply to a.c. three-phase systems with nominal voltage exceeding 1 kV, the nominal voltage is the voltage between phases.

If not otherwise stated herein, the requirements for construction and installation applicable to low voltage equipment (up to 1 kV) set out in the present Part of the Rules generally apply to high voltage equipment.

18.1.2 Nominal system voltage.

18.1.2.1 The nominal voltage of the electrical power distribution system is not to exceed values specified in Table 18.1.2.1.

Table 18.1.2.1

Rated interphase voltage, kV	Rated frequency, Hz
3 (3,3)	50 (60)
6 (6,6)	50 (60)
10 (11)	50 (60)
15	50 (60)

Note. Where necessary for special application, voltage higher than 15 kV may be accepted.

18.1.3 High-voltage, low-voltage segregation.

18.1.3.1 Electrical equipment with voltage above 1 kV is not to be installed in the same enclosure as low voltage equipment, unless segregation or other suitable measures are taken to ensure that access to low voltage equipment is obtained without danger.

18.1.3.2 Insulating materials used for electrical equipment are to ensure the insulation resistance of 1500 ohm per 1 V rated voltage, but not less than 2 megohms during continuous service of the unit.

18.1.3.3 Caution notes showing the voltage value are to be placed at the entrance to special electrical spaces. The enclosures of electrical equipment located outside the above spaces are also to be provided with such notes.

18.2 SYSTEM DESIGN

18.2.1 Distribution systems.

The following systems of electrical power distribution may be used for high-voltage alternating three-phase current plants:

insulated three-wire system;

three-wire system with the neutral earthed to the MODU or FOP hull through a high-value resistor or reactor;

four-wire system with directly earthed neutral.

18.2.1.1 Network configuration for continuity of unit services.

It is to be possible to split the main switchboard into at least two independent sections, by means of at least one intersectional circuit breaker or other suitable disconnecting devices, each supplied by at least one generator.

If two separate switchboards are provided and interconnected with cables, a circuit breaker is to be provided at each end of the cable. Services, which are duplicated, are to be supplied from different switchboards or to be divided between the sections.

18.2.1.2 Earthed neutral systems.

18.2.1.2.1 Neutral points of generators intended for operation in parallel may be connected to the common busbar before an earthing resistor or reactor on the switchboard or directly at the generator.

18.2.1.2.2 In case of earth fault, the leakage current is not to be greater than full load current of the largest generator on the switchboard or relevant switchboard section and not less than three times the minimum current required to operate any device against earth fault.

18.2.1.2.3 It is to be assured that at least one source neutral to ground connection is available whenever the system is in the energized mode.

Electrical equipment in directly earthed neutral or other systems with a neutral earthed to the hull through a high-value resistor or reactor is to withstand without damage the current due to a single phase fault against earth for the time necessary to trip the protection device.

18.2.1.3 Neutral disconnection.

Means of neutral disconnection are to be fitted in the neutral earthing connection of each generator so that the generator may be disconnected for maintenance and for insulation resistance measurement.

18.2.1.4 Hull connection of earthing impedance.

18.2.1.4.1 All earthing impedances are to be connected to the hull. The connection to the hull is to be so arranged that any circulating currents in the earth connections do not interfere with radio, radar, internal communication and control equipment circuits.

18.2.1.4.2 It is permitted to connect all resistors or reactors to a common earthing busbar, which is to be connected to the unit hull at least at two places.

18.2.1.5 Divided systems.

In the systems with neutral earthed, connection of the neutral to the hull is to be provided for each separate group of sections of the main switchboard.

18.2.2 Degrees of protection.

18.2.2.1 General.

Each part of the electrical installation is to be contained in an enclosure with a degree of protection appropriate to the location and the environmental effect. The requirements of IEC Publication 60092-201 may be considered as minimum.

18.2.2.2 Rotating machines.

The degree of protection of enclosures of rotating electrical machines is to be at least IP 23. The degree of protection of terminals is to be at least IP 44.

For motors installed in spaces accessible to unqualified personnel, a degree of protection of enclosure against approaching or contact with live or moving parts of at least IP 4X is required.

18.2.2.3 Transformers.

The degree of protection of enclosures of transformers is to be at least IP 23.

For transformers installed in spaces accessible to unqualified personnel, a degree of protection of at least IP 4X is required.

For transformers not contained in enclosures, see 18.7.1.

18.2.2.4 Switchgear, controlgear assemblies and converters.

The degree of protection of metal enclosed switchgear, controlgear assemblies and static converters is to be at least IP 32. For switchgear, controlgear assemblies and static converters installed in spaces accessible to unqualified personnel, a degree of protection of at least IP 4X is required.

18.2.3 Insulation.

18.2.3.1 Air clearance.

The air clearances between alive parts with different potentials or between alive parts and earthed metal parts or the casing is to be not less than specified in Table 18.2.3.1.

Table 18.2.3.1

Rated voltage (kV)	Minimum air clearance (mm)
3 (3.3)	55
6 (6.6)	90
10 (11)	120
15	160

Minimum air clearances for intermediate values of working voltages are to be selected as for the next higher standard voltage.

In the case of smaller distances, appropriate voltage impulse test shall be applied to support the admissibility of such a distance selected.

18.2.3.2 Creepage distances.

Creepage distances between parts under different potentials and between live parts and hull are to be in accordance with relevant national or international standards.

For non-standardised parts within the busbar section of a switchgear assembly, the minimum creepage distance is to be at least 25 mm/kV and behind current limiting devices, 16 mm/kV.

18.2.4 Protection.

18.2.4.1 Faults on the generator side of circuit breaker.

Besides the types of protection specified in 8.2, protective devices are to be provided against phase-to-phase faults in the cables connecting the generators to the main switchboard and against interwinding faults within the generators.

The protective devices are to trip the generator circuit breaker and to automatically de-excite the generator.

In distribution systems with a neutral directly earthed, phase to earth faults is also to be treated as above.

18.2.4.2 Faults to earth.

18.2.4.2.1 Any earth fault in the system is to be indicated (on control panels) by means of a visual and audible alarm.

18.2.4.2.2 In low impedance or directly earthed systems provision is to be made to automatic disconnection of the faulty circuits in case of earth fault.

18.2.4.2.3 In high impedance earthed systems (in systems with a neutral earthed through high-value resistor), where outgoing feeders will not be isolated in case of an earth fault, the insulation of the equipment supplied by these feeders is to be designed for the phase-to-phase voltage.

Notes: 1. A system is defined "effectively earthed" (low impedance) when the "earthening factor" is lower than 0,8. A system is defined "non-effectively earthed" (high impedance) when this factor is higher than 0,8.

2. "Earthing factor" is defined as the ratio between the phase to earth voltage of the health system and the phase-to-phase voltage.

18.2.4.3 Power transformers.

Power transformers are to be provided with overload and short circuit protection ensured by means of circuit breakers.

When transformers are connected in parallel, tripping of the protective devices at the primary side has to automatically trip the switch connected at the secondary side.

18.2.4.4 Voltage transformers for control and instrumentation.

Voltage transformers intended to supply control and instrumentation circuits are to be provided with overload and short circuit protection on the secondary side.

18.2.4.5 Fuses.

Fuses are to be used for short circuit protection.

Fuses are not be used for overload protection.

18.2.4.6 Low voltage systems.

Low voltage systems (up to 1 kV) supplied through transformers from high-voltage systems are to be protected against overvoltages at the secondary (low-voltage) side. This protection may be achieved by:

earthing of the lower voltage system;

appropriate neutral voltage limiters;

earthed screen between the primary and secondary windings of transformers.

18.2.4.7 Protective earthing.

Metal enclosures of electrical equipment are to be earthed with external copper flexible conductors having a cross-sectional area designed for a single-phase short-circuit current, but not less than 16 mm^2. Earthing wires are to be suitably marked.

Earthing conductors may be connected by welding or with bolts not less than 10 mm in diameter.

18.3 ROTATING MACHINERY (DESIGN REQUIREMENTS)

18.3.1 Stator windings of generators.

Generator stator windings are to have all phase and neutral ends brought out for the installation of the differential protection devices.

18.3.2 Temperature detectors.

Rotating machinery is to be provided with temperature detectors embedded in their stator windings to actuate a visual and audible alarm whenever the temperature exceeds the permissible limit.

If embedded temperature detectors are used, means are to be provided to protect the measuring circuit against overvoltage.

18.3.3 Tests.

In addition to the tests normally required for every rotating machinery, a high frequency high voltage test in accordance with IEC Publication

60034-15 is to be carried out on the individual coils in order to demonstrate a satisfactory level of resistance to the inter-turn short circuits caused by steep fronted voltage surges.

18.3.4 Design.

18.3.4.1 The machine housing, end brackets, protective guards of air intakes and outlets are to be made of steel alloys. Aluminium alloys for the above machine components are not permitted.

18.3.4.2 A drain, readily accessible for maintenance, is to be provided in the lower part of the machine housing for removal of condensate.

The rigidly secured baffle preventing ingress of water and other foreign objects into the machine is to be fitted on the top of vertical shaft machines. The lower end bracket is to be shaped so as to prevent accumulation of water in way of a bearing.

18.3.4.3 The terminal boxes of machinery are to be dimensioned so as to ensure:

necessary insulation distances between current-carrying parts and the housing;

necessary insulation distances between phases;

sufficient space for arrangement of connecting cable terminations and winding ends; and

the opportunity to change the arrangement of feeder entries up to four positions at an angle of 90°.

A separate terminal box is to be provided for instrument current transformers, a heating anticondensating element, temperature sensors, etc.

18.3.4.4 Stator winding leads are to enter into a separate terminal box, other than that for lower voltages, through a gasket.

A separate terminal box may be provided for neutral leads.

Terminals for earthing conductors of cables are to be provided inside terminal boxes. The reliable electrical connection is to be ensured in this case between the motor housing and the box body.

18.3.4.5 The motors rated at 1000 kW and over are to be fitted with differential protection devices. For this purpose, the motor housing is to be provided with a separate terminal box, located on the side opposite to the main terminal box, in which positions for three current transformers and the leads of neutral winding ends are to be provided.

18.3.4.6 The temperature of bearings of motors rated at 1000 kW and over is to be monitored with local indicators (instruments). Each bearing is to be also provided with temperature sensors for remote monitoring.

18.3.4.7 In order to prevent the harmful effect of bearing currents, the bearing on the side opposite to the dive is to be electrically insulated from the housing. Provision is to be made for measuring insulation resistance for the insulated bearing without its assembly.

18.3.4.8 The plain bearing design is to provide for:

local indicators of the lubricating oil level;

a separate pump with a local pipeline, tank, cooler, filter and flow rate indicator when forced circulating lubrication is used;

the possibility of installation of vibration monitoring instruments including necessary cable lines, as well as the instruments for measuring bearing wear;

interlocking of the motor starting when the lubricant is lacking.

18.4 POWER TRANSFORMERS

18.4.1 General.

18.4.1.1 Dry type transformers are to comply with IEC Publication 60726.

The dry type transformers used are to be provided with earthed screens between the windings of high and low voltages.

Liquid cooled transformers are to comply with IEC Publication 60076.

Cooling oil immersed transformers are to be provided at least with the following alarms and protections:

"Minimum liquid level" – alarm and trip;

"Maximum liquid temperature" – alarm and trip or load reduction;

"High gas pressure in enclosure" – trip.

18.4.1.2 Transformers installed in spaces accessible to unqualified personnel are to have the degree of protection of enclosure not lower than IP 4X.

18.4.1.3 Where the low-voltage side of the transformers has an insulated neutral point, a spark-discharging fuse is to be provided between the neutral point of each transformer and the unit hull. The fuse is to be rated for not less than 80 per cent of the minimum test voltage for the devices fed through the given transformer.

18.4.1.4 It is permitted to connect in parallel to the discharger the apparatus for monitoring insulation condition on low-voltage side of the installation or for detecting the location where this insulation is damaged. Such apparatus is not to interfere with reliable operation of the discharger.

18.4.1.5 Effective means (e.g. heating) are to be provided to prevent the accumulation and condensation of moisture inside the transformers when they are de-energised.

18.5 CABLES

18.5.1 General.

Cables are to be constructed in accordance with the IEC Publications 60092-353 and 60092-354 or other equivalent national standard.

18.5.1.1 Triple-core cables with multiwire cores are to be used for a three-phase cable network. The cross-sectional area of the cable conductor for power circuits is to be not less than 10 mm^2.

18.5.1.2 The structure, type and permissible current loads of the cables used are subject to special consideration by the Register in each case.

18.6 SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

Table 18.6.2.1.3

Rated voltage, kV	Minimum passageway height, mm	Minimum distance of alive electrical parts from different protective guards, mm		
		continuous doors and bulkheads	net doors and screens	insulated handrails
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

18.6.1 General.

Switchgear and switchcontrol assemblies are to be constructed according to IEC Publication 60298 and the following additional requirements.

18.6.2 Construction.

18.6.2.1 Mechanical construction.

Switchgear is to be of metal-enclosed type in accordance with IEC Publication 60298 or of the insulation-enclosed type in accordance with IEC Publication 60466 or in accordance with the requirements of national standards.

18.6.2.1.1 Switchboards are to be locked with a special key other than for the low-voltage switchboards and switchgear. Opening of doors or withdrawal of separate elements is to be feasible only after the disconnection of the panel concerned or the whole switchboard from the electrical network.

18.6.2.1.2 Passageways are to be provided along the switchboards for inspection of the switchboard and electrical apparatus and the width of the passageways is to be at least 800 mm between the bulkhead and the switchboard, and at least 1000 mm between the parallel sections of the switchboard. Where such passageways are intended for maintenance, their width is to be increased up to 1000 mm and 1200 mm, respectively.

The above width of these passageways is required irrespective of the means used for protection against contact, like doors, a guard net or insulated handrails.

Doors, continuous bulkheads and net screens are to be at least 1800 mm high.

Perforated or net screens are to provide for the protection type not below IP 2X.

Two rows of insulated handrails are to be fitted along the switchboard at the heights of 600 mm and 1200 mm.

18.6.2.1.3 Alive parts of the electrical installation are to be separated from the protective guards by a distance not less than specified in Table 18.6.2.1.3.

18.6.2.2 Locking facilities.

Withdrawable circuit breakers and switches used in the switchboards are to be provided with mechanical locking facilities in both service and disconnected positions. For maintenance purposes, key locking of withdrawable circuit breakers and switches and fixed disconnectors is to be possible.

Withdrawable circuit breakers are to 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 contacts of withdrawable circuit breakers and switches are to be so arranged that in the withdrawable position the live contacts are automatically covered.

18.6.2.4 Earthing and short-circuiting devices.

For maintenance of the high-voltage switchgear assemblies for collecting busbars and outgoing feeders, an adequate number of earthening and short-circuiting devices is to be provided to enable circuits to be worked upon with safety.

Such device is to be designed for the maximum short-circuit current. On agreement with the Register, such a device may be portable.

18.6.3 Auxiliary supply systems.

18.6.3.1 Source of supply.

If a separate auxiliary source of electrical or other energy is required for the operation of circuit breakers and switches, in addition to the main source a reserve source is to be provided and the store supply of that source is to be sufficient for at least two operations of all the components.

However, the tripping due to overload or short-circuit, and under-voltage is to be independent of any stored electrical energy sources.

This does not preclude shunt tripping, i.e. operating from the control voltage, provided that the continuity of the release circuits and their power supply systems is monitored, that is alarms are activated on control panels upon lack of continuity in the release circuits and power supply failures.

18.6.3.2 Number of supply sources.

For the splitted main switchboards (see 18.2.1.1), at least one independent reserve source of supply to operate circuit breakers and switches is to be provided in addition to their own sources of energy each supplied from its system of busbars. Where necessary, this source of supply is to be from the emergency source of electrical power for the start up from dead ship condition.

18.6.3.3 High voltage test.

A power-frequency high voltage test is to be carried out on any switchgear and controlgear assemblies. The test procedure and voltages are to be according to the relevant national Standard or to IEC Publication 60298.

18.7 INSTALLATION

18.7.1 Electrical equipment.

18.7.1.1 Where high-voltage equipment is not contained in an enclosure but a room forms the enclosure of the equipment, the access doors are to be so interlocked that they cannot be opened until the supply is isolated and the equipment earthed down.

At the entrance of the spaces or rooms where high-voltage equipment is installed, a suitable marking is to be placed, which indicates danger of high-voltage.

18.7.1.2 In well-grounded cases, the electrical equipment may be installed outside special electrical spaces, provided the degree of protection is not below IP 44 and access to current-carrying parts may be possible only in case the voltage is off or when special tools are used.

18.7.1.3 The connection circuit diagram and the plan of electrical equipment arrangement are to be available in the special electrical space.

18.7.2 Cables.

18.7.2.1 Runs of cables.

Cables are not to run through accommodation spaces. However, if this is required by the conditions of technological nature, high-voltage cables may be permitted to be run in accommodation spaces in special enclosed cable transit systems.

18.7.2.2 Segregation.

High-voltage cables are to be segregated from cables operating at the voltages below 1000 V. In particular, the high-voltage cables are not to be run in the same cable bunch, nor in the same ducts or pipes, or, in the same box.

Where high-voltage cables of different voltage ratings are installed on the same cable tray, the air clearance between cables is not to be less than the minimum air clearance for the higher voltage cables as specified in 18.2.3.1.

However, high-voltage cables are not to be installed on the same cable tray for the cables operating at the nominal system voltage of 1 kV and less.

18.7.2.3 Installation arrangements.

High-voltage cables are to be laid in metallic pipes or boxes, or they are to be protected with metallic enclosures.

The open installation of cables (on carrier plating) is permitted if they are provided with continuous metallic armour effectively (repeatedly) bonded to earth.

18.7.2.4 Terminations.

Terminations in all conductors of high-voltage cables are to be effectively covered with suitable insulating material. In terminal boxes, if conductors are not insulated, phases are to be separated from earth and from each other by substantial barriers of suitable insulating materials. High-voltage cables having a conductive layer between phases to control the electric field within the insulation, are to have terminations, which provide electric stress control.

Terminations are to be of a type compatible with the insulation and jacket material of the cable and are to be provided with means to ground all metallic shielding components (i.e. tapes, wires etc.).

18.7.2.5 Marking.

High-voltage cables are to be readily identifiable by suitable marking.

18.7.2.6 Test after installation.

Before a new high-voltage cable installation is put into service or after its modernisation (repair or installation of additional cables) a high voltage withstand test is to be satisfactorily carried out on each completed cable and its accessories (terminations, earthing leads, etc.)

The test is to be carried out after an insulation resistance test.

When a d.c. voltage withstand test is carried out, the voltage is to be not less than:

1,6 ($2{,}5U_o + 2$kV) for cables of rated voltage (U_o) up to and including 3,6 kV;

4,2U_o for higher rated voltages, where U_o is the rated power frequency a.c. voltage between each conductor and earth or metallic screen, for which the cable is designed.

The test voltage is to be maintained for a minimum 15 min.

After completion of the test the conductors are to be connected to earth for a sufficient period in order to remove any trapped electric charge.

An insulation resistance test is then repeated.

Alternatively, an a.c. high voltage withstand test may be carried out upon advice from high voltage cable manufacturer at a voltage not less than normal operating voltage of the cable and is to be maintained for a minimum of 24 h.

N o t e. Tests according to those specified in IEC Publication 60502 will be also considered adequate."

19 SPARE PARTS

19.1 GENERAL

19.1.1 Each MODU or FOP is to have the store of spare parts for an electrical installation in the amount not less than specified in this Section.

19.1.2 The list and amount of spare parts for electric propulsion plants, electric couplings, self-excitation and automatic voltage regulation systems of generators, and automation systems, whose type is not specified in Table 19.2, are, in each case, subject to special consideration by the Register.

19.1.3 Spare parts are to be ready for use without additional working and fitting.

19.1.4 Spare parts are to meet the requirements of this Part. After manufacturing, spare parts are to be tested.

19.1.5 Spare parts are to be secured in accessible places, duly marked and reliably protected against environmental effects.

19.1.6 The installed equipment is to be provided with a set of special tools and fixtures necessary for its disassembly and assembly in operational conditions.

The unit is to be provided with necessary materials for maintaining accumulator batteries (distilled water, acid, alkali), with cables and wires, fuse links of all sizes for fuses, insulating materials, as well as with the materials which may be needed for eliminating faults of the electrical equipment.

19.1.7 Spare parts are optional for the electric drives of machinery where such machinery is installed in duplicate, used according to its direct functions and the output (capacity) of each mechanism installed is adequate.

Spare parts are optional for the generators of an electric generating plant provided that it is equipped with generators of adequate power in number exceeding the requirements of this Part.

19.2 SPARE PARTS STANDARDS

19.2.1 Each MODU or FOP is to be provided with spare parts relating to electrical equipment which are specified in Table 19.2.

Table 19.2

Equipment	Spare parts	Number	Notes
Generators	Brushes Brush holders Bearings	1 set each	For 3 generators of the same type
Static converters	Semiconductor elements	1 pc each	For 3 exciters or 1 block as a unit
Electric motors	Brushes Brush holders Bearings	1 set each	For 6 motors of the same type
Main and emergency switchboards, distributing boards, control panels, starting equipment	Circuit breakers, packet switches, voltage coils, fuses, pilot lamps, etc.	1 pc each of each type	Of each type for 6 devices
Switchboard instruments	Instruments as a unit	1 pc each	For 10 of the same type
General alarm system	Acoustic instruments		According to manufacturer's recommendation
Service telephone communication system	Telephone sets		According to manufacturer's recommendation
Lighting	Incandescent and luminescent lamps	30 per cent of installed lamps	
Portable instruments	Ammeter, voltmeter, megger, etc.	1 pc each	

PART XI. REFRIGERATING PLANTS

1 GENERAL

1.1 The refrigerating plants installed stationary onboard the MODU or FOP are to meet the requirements of Sections 1 to 8, 11 and 12 of Part XII "Refrigerating Plants" of the Rules for the Classification and Construction of Sea-Going Ships.

PART XII. MATERIALS

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part apply to materials and products intended for welded structures, components of machinery and equipment of MODU/FOP, subject to supervision of the Register in compliance with the requirements of other parts of MODU/FOP Rules.

1.1.2 The materials and products to be supervised in the course of their manufacture are to meet the requirements of the present Part and Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. It is permitted, after special consideration by the Register, to accept materials and products complying with the requirements of national and international standards approved by the Register.

The materials differing in chemical composition, mechanical properties, condition as supplied or process of manufacture from those indicated in the present Part are to be considered by the Register. In this case data is to be submitted which confirm the possibility of these materials application in accordance with their purpose. The Register may also require additional testing.

1.1.3 The materials and products subject to supervision of the Register, are to be produced by the manufacturers recognized by the Register and having the following documents:

Recognition Certificate for Manufacturer;

Type Approval Certificate.

The procedure of issue of the above certificates has been established in 1.1.4 and 1.3.2, Part XIII "Materials" in the Rules for the Classification and Construction of Sea-Going Ships. The documents are issued on the basis of the firm survey and on the positive results of testing confirming the compliance of the products in question, manufactured using the technologies adopted at the firm, with the requirements of MODU/FOP Rules.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 The definitions and explanations relating to the general terminology are given in Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

1.2.2 In the present Part the following definitions have been adopted.

Recognized firm means the one included in the List of approved (recognized) materials and manufacturers published by the Register.

Recognized laboratory means a laboratory (centre) included into the List of laboratories (centres) having Recognition Certificates.

Recognition Certificate for Manufacturer is a document confirming the compliance of manufactured products and conditions of their manufacture at the given firm with the requirements of the Register Rules and certifying the firm entry into the appropriate List published by the Register.

Type Approval Certificate is a document confirming the compliance of the products manufactured by the firm with requirements of the Register Rules and certifying the firm entry into the appropriate List published by the Register.

Register Certificate is a document certifying the compliance of a certain volume of particular products with requirements of the Register Rules and, if so specified, with requirements of the order. The Certificate is issued by the Register inspector supervising manufacture of the products.

Manufacturer's Certificate is a document of the firm certifying the compliance of a certain volume of particular products with requirements of the order and confirming the manufacture of the products in full compliance with the production technology adopted at the firm. The Certificate is issued by the firm and is to be certified by signature of the responsible person representing the quality control department of the firm.

Register Brand in the present Part means a brand, stamp or seal of a certain type regulated by the Register, which can be applied to finished products or in the course of manufacture to confirm the Register supervision and product identification in accordance with the documents issued for them.

Sample means a part of semifinished product or a specially prepared blank intended for making specimens for tests.

Specimen means a product of specified shape and dimensions cut out of the sample and intended for direct evaluation of mechanical, technological and other properties of the material by testing.

S e m i f i n i s h e d p r o d u c t means a plate, forging, casting, pipe, etc., which subsequently, when used for intended purpose, will be subjected to mechanical treatment or processing.

B a t c h means a limited number of semifinished products for which the results of tests conducted in accordance with the established procedure are valid.

I n i t i a l t e s t s means a specified scope of check tests regulated by a special program approved by the Register and carried out during a survey of the firm by the Register with the aim of granting the Recognition Certificate for Manufacturer to this firm.

A c c e p t a n c e t e s t s means a scope of testing established by the Register Rules or by documentation approved by the Register for products supplied under the Register supervision; the results of such tests can serve as a basis for issue of Register Certificates.

Z - s t e e l means steel with guaranteed through-thickness properties which is intended for welded structures and can withstand considerable stresses perpendicular to the plate surface.

L a m e l l a r r u p t u r e means failure of elements of welded structures made of rolled plates or pipes due to considerable welding stresses and/or external loads acting in the direction perpendicular to the rolling surface.

N o n - s t a b l e f a i l u r e o f s p e c i m e n means full or partial destruction (crack overshoot) of the specimen, at which falling of load is recorded, as well as non-controlled rising of displacements by more than 1 per cent.

1.3 SCOPE OF SUPERVISION

1.3.1 The regulating provisions for the procedures and scope of supervision are set out in General Regulations for the Classification and Other Activity and 1.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

1.3.2 The supervision and appropriate tests in the course of materials manufacture are carried out within the scope of requirements of the present Part.

1.3.2.1 The scope and procedures for testing required for granting of the Recognition Certificate for Manufacturer are determined, in the general case, based on the requirements of Sections 3 and 4. The test program is drafted by the firm and submitted to the Register for approval.

As a rule, the draft test program for the initial survey of the firm is to contain:

.1 determination of chemical composition (ladle sample and semifinished product);

.2 tensile tests;

.3 impact bending tests (longitudinal and transverse specimens);

.4 bending tests;

.5 strain ageing sensitivity tests;

.6 macroscopic analysis;

.7 microscopic analysis;

.8 determination of sulphur liquation in homogeneity.

Besides, test results or conduction of testing may be requested for determination of:

.9 crack resistance parameter (CTOD) for base metal and HAZ metal of welded joints. CTOD is to be determined at the temperature corresponding to the steel grade (A, B, D, E, F) specified, as well as at other temperatures defined by test programme;

.10 nil-ductility temperature (NDT);

.11 ductile-brittle transition temperature (T_{kb}) for base metal, etc.

1.3.2.2 If the application conditions require confirmation of special properties of the material, the test results or conduction of the following test are necessary:

.1 tension at elevated temperatures;

.2 material fatigue tests;

.3 determination of corrosion resistance;

.4 corrosion fatigue tests.

1.3.2.3 All the tests are to be carried out in the presence of a Register representative following the procedures agreed upon by the Register.

1.3.2.4 In a general case, tests of any brand steel submitted for initial approval are to be carried out using metal specimens of at least two melts. The samples for preparation of test specimens are to be selected from at least two semifinished products of different thickness (maximum, average, or minimum values of those indicated in the request) for each melt. If in the request for firm recognition several types of semifinished products are listed, e.g. plate, section, rod, etc., then the procedure mentioned above is to be used for each type of semifinished products.

Depending on statistical data submitted by the firm and showing the quality stability level of the supplied products, the quantity of melts and semifinished products delivered for testing can be changed.

1.3.2.5 The satisfactory results of tests on a higher grade steel can be considered valid for a steel of lower grade, if the production process, chemical composition and delivery terms are identical for both grades. If the above conditions are observed, the positive results of strength level 36 steel testing can be extended to include a steel of strength level 32.

1.3.2.6 The impact bending tests are to be carried out using longitudinal and transverse specimens taken from two ends of the semifinished product submitted for testing.

As a rule, the tests are to be conducted at +20°, 0 °C, −20 °C, −40 °C and −60 °C, steel of grade F is to be additionally tested at −80 °C. The tests are to result in plotting of a diagram of impact performance versus test temperature, indicating also the percentage of ductile (brittle) component in the specimen fracture. Unless otherwise specified, the tests in the given scope are performed as a part of the initial tests, when modifications are introduced into the production process, and can be requested by the Register for confirmation of the Recognition Certificate.

1.3.2.7 The strain ageing sensitivity tests are carried out using specimens cut out of samples, which are selected similarly to samples for impact bending tests. The metal flats, from which the specimens are to be cut, are subjected to tensile strain producing 10 per cent of residual elongation. The impact bending test specimens prepared from flats subjected to strain tension are to be preheated uniformly (aged artificially) up to 250 °C, then exposed to this temperature for one hour and subsequently cooled in the air. The impact bending specimens are tested at room temperature (within 18 to 25 °C) and at the temperature appropriate for the indicated grade of steel (for instance, −20 °C for steel grade D32). Unless otherwise specified, these tests are performed at the initial survey of the firm, also in cases of introduction of modifications into the steel production process and when demanded by the Register surveyor in controversial or questionable cases concerning the quality of rolled products.

1.3.2.8 The macroscopic analysis is performed for determination of deformed metal structure, detection of discontinuities, flakes, etc. As a rule, for macroscopic analysis transverse specimens are taken (for rods, profiles — over the full cross-section) from the forward end of the head semifinished product or forward end of the feed. Unless otherwise specified, the macroscopic analysis is required at the initial survey of the firm, when modifications are introduced into the production process and when demanded by the Register surveyor in controversial or questionable cases concerning the quality of the supplied rolled products.

1.3.2.9 The microscopic analysis is performed for determination of steel grain, size in the course of operation and for evaluation of sensitivity to grain size increase when heated. The actual and natural grain is defined. Metal-graphic specimens (microsections) are manufactured in various sections of semifinished product. Microsections of rolled metal are taken from the middle of semifinished product thickness or from a layer of 1/3 or 1/4 under the surface (depending on the total thickness). The microsections are normally prepared from longitudinal specimens cut out of the front end of the head semifinished product or head part of the feed. The analysis is carried out using pickled and non-pickled microsections with magnification of 100 and/or 400. Unless otherwise specified, the macroscopic analysis is required at the initial survey of the firm, when modifications are introduced into the production process and when demanded by the Register surveyor in controversial or questionable cases concerning the quality of the supplied rolled products.

1.3.2.10 When different methods of melting are employed at the firm, including the classic way of casting into ingot moulds, or use of continuous casting of steel, also when rolling the semifinished product indicated in the application for recognition at various mills, etc., the requirement stated above is to be applied for each technological chain separately.

2 TEST METHODS

2.1 GENERAL

2.1.1 Testing of materials to be supervised during manufacture is to be carried out in accordance with the requirements of Section 2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and of the national and international standards recognized by the Register.

2.1.2 To be separately agreed upon by the Register are test procedures for determination of:

.1 crack resistance properties of base metal and metal of welded joints (CTOD);

.2 nil-ductility temperature (NDT);

.3 ductile-brittle transition temperature (T_{kb}).

Requirements for tests indicated above are listed in 2.2 to 2.4.

2.2 CTOD TESTS

2.2.1 General.

2.2.1.1 The principal goal of testing is control over certain type of material fracture in presence of a crack within the climatic temperature range. The tests are to define the crack resistance parameter CTOD (crack tip opening displacement) at static loading.

The CTOD is one of the listed below crack opening values connected with a certain type of crack propagation and calculated in accordance with the recognized standards:

δ_c — when before the beginning of non-stable fracture (brittle crack propagation) its mean stable extention was less than 0,2 mm;

δ_n — when before the beginning of non-stable fracture (brittle crack propagation) its mean stable extention exceeded 0,2 mm;

δ_m — when the maximum load was reached without non-stable fracture.

2.2.1.2 To define the CTOD value fatique pre-cracked specimens are used and tested at a specified travel speed of the test machine loading cross-piece ensuring the stress intensity factor growth rate within (0,5 ... 1,5)$\mathrm{MPa{\cdot}m^{1/2}/s}$ during linear elastic specimen deformation. The specimens are loaded up to the fracture (total or partial) or until the maximum force recorded in plastic deformation is exceeded.

2.2.2 Specimens for CTOD testing.

2.2.2.1 Samples for preparation of specimens for CTOD testing are to be taken from areas nearest to those where samples for tensile and impact bending tests are taken.

2.2.2.2 Orientation of specimens in the course of manufacture is to be such, unless otherwise specified, that the direction of crack propagation will coincide with the direction of the last rolling (principal direction of metal deformation).

2.2.2.3 When it is not possible to perform testing of specimens close to the full product thickness, it is permitted, by agreement with the Register, to conduct tests on specimens of lower thickness with side grooves preventing formation of shear lips. The depth of the groove is to be equal to 0,10 to 0,15 of the specimen thickness.

2.2.2.4 It is permitted to test specimens manufactured from semifinished products having angular deformations and curvature (for example, pipes). In such cases the samples can be straightened taking care that load application points are located at a distance of at least equal to the specimen thickness from the line of notch, and the notch zone must not suffer from strains affecting the test results.

2.2.2.5 For specimens with residual stress and those subjected to straightening, mechanical removal of residual stress is permitted. The heat treatment in this case is not allowed. It is recommended to use for mechanical relieving of residual stress a method consisting in local compression of specimen side surfaces applied in the notch tip zone, with plastic deformation of the specimen not exceeding 0,5 per cent of the specimen thickness on each side. For this purpose punches of sufficient pressure area are to be used to achieve specimen covering in one run if possible. It is necessary to ensure the notch tip covering.

2.2.2.6 When evaluating the crack resistance of the HAZ (heat affected zone) the notch is to be made so that the crack tip, on the largest possible length of its front, could be located in a layer of supposedly minimum toughness. To achieve this, it is recommended to use welding with special edge preparation (K- or V- weld). The technological process of welding is to be approved by the Register. Special attention is to be paid to employed welding consumables and heat input. Before application of marking and before notching the specimen, it is necessary to perform the etching and to investigate the heat affected zone metal structure. Unless otherwise indicated, considered as the minimum toughness zone is to be a zone of the largest grain size and maximum overheating at welding. If so required by the Register, the tests may be carried out with notches made in other zones. The accuracy of the obtained results in this case is to be attained by increasing the number of tested specimens (up to 8 — 10 per one test temperature) and rejecting after the test those, in which the crack overreached the limits of the zone under study, as specified by conditions of test correctness indicated in 2.2.5. To make rejection after testing, it is necessary to define the actual position of the initial crack and path of its propagation; to do this, preparation of transverse microsections may be required, as well as repeated etching and detection of structural components over which the destruction was proceeding.

2.2.3 Types of specimens.

2.2.3.1 For the purpose of testing specimens of the following types are prepared:

.1 rectangular cross-section specimens for three-point bending;

.2 compact specimens for eccentric tension.

For semifinished products with thickness not exceeding 50 mm specimens of type 2.2.3.1.1 are recommended. The specimen thickness is to be, as far as possible, close to the full thickness of the semifinished product.

2.2.3.2 For semifinished products with thickness equal to or above 50 mm compact specimens are recommended, as requiring less metal. The thickness of compact specimens is to be of maximum possible value for the following range: 50 mm, 75 mm, 100 mm.

Dimensional ratios of the specimens and methods of their manufacture are to correspond to standards recognized by the Register.

2.2.4 Equipment, jigs and fixtures, instrumentation.

2.2.4.1 In general cases the equipment, jigs and fixtures, as well as measuring apparatus are to meet the requirements of the standards and MODU/FOP Rules and are to be periodically checked and calibrated by authorized national bodies.

2.2.4.2 Employed as the machines for testing are to be hydraulic servomotor-operated, or similar facilities with the upper limit of operating load range between 100 and 2500 kN capable of applying force at rates specified by 2.2.1 and force measuring error not exceeding $\pm 0,1$ per cent of the operating range upper limit. The systems for measuring of applied forces and recording of the results are to allow the applied force to be recorded against notch edges opening.

2.2.4.3 The jigs and fixtures for three-point bend tests are to allow the support rollers to rotate and move apart slightly, thus maintaining rolling contact throughout the test. The roller diameter is to be from 0,5 to 1,0 of the specimen height.

2.2.4.4 The arrangements for loading of compact specimens (clevis and pin) are to permit alingment as the specimen is loaded, for which purpose the gap between the specimen and clevis inner surfaces is to be increased to 0,5 to 1,0 mm and shall prevent pins jamming during the specimen plastic deformation.

2.2.4.5 The error in test temperature measurement is not to exceed ± 5 °C. The temperature is to be measured by thermoelectric temperature transducers provided with secondary measuring devices complying with the accuracy grade not lower than 0,5.

2.2.4.6 The crack edges opening is measured by means of displacement gauges with base length of minimum 10 mm, with measuring range from ± 10 per cent to ± 50 per cent counting from the base. If the above are employed, the displacement measuring error is not to exceed $\pm 1,5$ per cent from the upper boundary of the operating range.

2.2.4.7 The displacement gauges are to be subjected to a calibration check before starting a new series of measurements of identical specimens. It is especially important for low temperature testing. If a gauge is properly isolated from the specimen, the calibration may be done at room temperature. The calibration error is not to exceed $\pm 0,01$ mm.

2.2.5 Validity conditions of received CTOD values.

2.2.5.1 The geometrical dimensions of specimens are to be within the standard tolerances.

2.2.5.2 The crack length/specimen height ratio is to be within the range from 0,45 to 0,55 for all types of specimens.

2.2.5.3 The fatique crack extent is to make at least: 1,3 mm or 2,5 per cent of the specimen height whichever is the greater.

2.2.5.4 The difference between any two measurements of the initial fatigue crack length is not to exceed 10 per cent of the crack length mean value for the above measurements. When making the measurements in the heat affected zone, the tolerance may be increased to 20 per cent.

2.2.5.5 When testing the metal of heat affected zone, it is considered sufficient if the initial fatigue crack front contains a specified microstructure portion with the length equal to 15 per cent of the specimen thickness, unless otherwise specified.

2.2.6 Determination of the CTOD test result.

When evaluating the crack resistance parameter CTOD for base metal and HAZ metal, the minimum quantity of correct specimens tested at the same temperature is to be not less than three.

The CTOD value is to be determined as the mean value of the test results under the following conditions:

when testing three correct specimens, none of the obtained results is to be equal to less than 70 per cent of the mean value for the base metal and less than 50 per cent for the HAZ metal;

when testing five or more correct specimens, none of the obtained results is to be equal to less than 50 per cent of the mean value for both the base metal and HAZ metal.

Where the above conditions are not complied with, the minimum recorded value of this parameter is to be taken as CTOD value.

2.3 DROP-WEIGHT TESTING FOR DETERMINATION OF NIL-DUCTILITY TEMPERATURE

2.3.1 General.

2.3.1.1 The main purpose of the testing is determination of brittle fracture development conditions in a material with thickness of at least 15 mm.

2.3.1.2 The test consists in impact bend loading of a number of specimens provided by a free-falling weight at a sequence of temperatures aimed at determination of a highest temperature at which standard specimens break, or nil-ductility temperature (NDT).

The deflection of the specimens is to comply with the standards and be limited by a stop.

2.3.2 Specimens for NDT determination.

2.3.2.1 The samples used for NDT test specimens are to be taken from places closest to places from which the samples for mechanical testing were taken. If for taking the samples gas cutting is used, the allowance for machining on each side is not to be less than 25 mm or not less than the semifinished product thickness, whichever is larger.

2.3.2.2 The specimen orientation in their manufacture, unless otherwise specified, is to be such that the longitudinal axes are perpendicular to the last semifinished product rolling direction (predominant direction of metal deformation).

2.3.2.3 It is recommended to perform NDT determination for a series of nine specimens.

2.3.2.4 The specimen dimensions are selected from Table 2.3.2.4 observing the condition that the specimen thickness is to be closest to the thickness of the product subjected for the testing.

Table 2.3.2.4

Specimen type	1	2	3
Length, mm	$360 \pm 2{,}0$	$130 \pm 1{,}0$	$130 \pm 1{,}0$
Width, mm	$90 \pm 2{,}0$	$50 \pm 1{,}0$	$50 \pm 1{,}0$
Thickness, mm	$25 \pm 2{,}5$	$19 \pm 1{,}0$	$15 \pm 1{,}0$

2.3.2.5 Specimens are prepared, as a rule, by a mechanical method. No overheating of specimens is allowed. The specimen tension side is not to be subjected to machining.

2.3.2.6 Employed for testing are rectangular specimens with brittle weld deposit on the non-machined tension side. In the deposit a notch is made across the specimen, from which a crack is propagated under an impact load.

2.3.2.7 Only the deposited metal shall be notched. The parameters to be controlled are:

the weld thickness under the notch bottom — 2 to 0,2 mm;

maximum width of the notch — 1,5 mm.

2.3.2.8 The electrodes for brittle overlay (deposit) are to have the core diameter of 4 to 6 mm. Each batch of electrodes is to be checked to perform satisfactory as follows:

in addition to the main series of specimens of the product under study three more specimens of type 2 (see Table 2.3.2.4) are to be manufactured which, after a preliminary estimation of NDT temperature, are to be tested at a temperature of not lower than NDT +60 °C. Each of the tested specimens is to present a visually detected crack propagating from the notch in the deposited metal.

2.3.2.9 The brittle weld is to be deposited in a single run, placing it along the specimen in the centre of non-machined surface. The width of the deposit is to be 13 ± 2 mm, length 65 ± 5 mm, the bead height, approximately uniform along the whole length, is to be at least 4 mm, which can be achieved by selecting the appropriate welding procedures.

2.3.3 Equipment, jigs and fixtures, instrumentation.

2.3.3.1 The equipment, jigs and fixtures and instrumentation are to comply with the requirements of the standards and MODU/FOP Rules and are to be periodically checked and calibrated by authorized national bodies.

2.3.3.2 The tests are carried out at an impact testing machine with a free-falling weight ensuring the impact energy from 330 to 1750 J. The necessary level of energy for a particular material and size of product is selected in accordance with the standards. The anvil manufactured of solid metal is to have hardness of 50 — 55 HRC.

2.3.4 Validity conditions of obtained NDT values:

.1 the geometrical dimensions of the specimens are to be within the limits of standard tolerances;

.2 the weld-deposit notch is visibly cracked;

.3 the specimens in the course of bending reach the stop;

.4 the deposited layer on the specimens does not contact with the anvil;

.5 the obtained value of the nil-ductility temperature is confirmed by testing of three specimens at the temperature of NDT + 5 °C, none of which was broken;

.6 the fitness of the electrodes used for brittle deposit has been proved.

2.4 TESTS FOR DETERMINATION OF DUCTILE-TO-BRITTLE TRANSITION TEMPERATURE (T_{kb})

2.4.1 General.

2.4.1.1 The T_{kb} temperature is a ductile-to-brittle transition temperature characterised by 70 per cent fibrous component in the fracture of a full-thickness specimen. The tests carried out for determination of T_{kb} allow evaluating cold resistance of the tested material, to compare cold resistance of various steels as well as to evaluate the temperature of brittle crack arrest T_{ar} in tested material, proceeding from the condition $T_{ar} = 0{,}9T_{kb} - 10$ °C.

2.4.1.2 The procedure for T_{kb} measurement involves the three-point bend testing of a series of steel specimens in full thickness till fracture. The tests are carried out at successively lowered temperatures.

2.4.1.3 In the course of testing control is effected over the area of crystalline (brittle) or fibrous (ductile) components in the specimen fracture and over the test temperature.

Moreover, upon completion of the tests, control is effected over the existence of cleavage in the fracture within the fibrous component. With cleavage existing, the tests are considered as invalid, if the cleavage reaches the boundary between the ductile and brittle components of the fracture or extends for more than one-half the specimen thickness.

2.4.1.4 To plot the temperature curve, it is recommended to carry out the tests in the following temperature sequence: +20 °C, 0 °C, −20 °C, −40 °C, −60 °C, and so on, depending on the grade of steel to be tested, but with intervals not exceeding 20 °C.

2.4.2 Specimens for determination of T_{kb}.

2.4.2.1 The samples used for preparation of T_{kb} specimens are to be taken from places closest to those from which the samples for mechanical testing were taken.

2.4.2.2 The specimen orientation, unless otherwise specified, is to be such that the longitudinal axes are perpendicular to the last rolling direction (principal direction of metal deformation). Orientation of each specimen is indicated in the test record.

2.4.2.3 It is recommended to determine T_{kb} by testing a series of 10 to 12 specimens.

2.4.2.4 The specimens are to be prepared using a mechanical method. If agreed upon by the Register and testing body, it is permitted to use gas or plasma cutting for specimen cutting, provided that the bearing and loaded surfaces are subjected to machining to provide parallelism between them and perpendicularity of the plate.

Upon agreement with the Register, it is permitted to make notch using gas cutting.

2.4.2.5 The dimensions of specimens made of metal in full thickness are to meet the requirements of Table 2.4.2.5. The radius of notch in flat prizmatic specimens is to be equal to half the notch width.

Table 2.4.2.5

Thickness, mm	Length, mm	Height, mm	Notch depth, mm	Notch width, mm
Above 10 to 14	288 + 20	60 + 5	20 + 5	3 + 3
Above 14 to 32	400 + 20	90 + 5	30 + 5	3 + 3
Above 32 to 60	520 + 20	120 + 5	40 + 5	5 + 5
Above 60 to 100	640 + 20	150 + 5	75 + 5	5 + 5
Above 100	6 thicknesses + 20	1,5 thicknesses + 5	0,75 thickness + 5	10 + 5

2.4.3 Equipment, jigs and fixtures, instrumentation.

2.4.3.1 The equipment, jigs and fixtures and instrumentation are to comply with the requirements of the standards and MODU/FOP Rules and are to be periodically checked and calibrated by authorized national bodies.

2.4.3.2 It is not recommended to use mechanically operated machines for determination of T_{kb}.

2.4.4 Validity conditions of obtained T_{kb} values.

2.4.4.1 The geometrical dimensions of the specimens are to be within the limits of standard tolerances.

2.4.4.2 The error of the required specimen temperature measurement in its notched cross-section does not exceed ±2 °C within the range from +150 to −200 °C.

2.4.4.3 The error in determination of the quantity of fibrous or crystalline component in the specimen fracture does not exceed ±5 per cent of the fracture area.

2.4.4.4 The obtained value of T_{kb} is confirmed by testing of three specimens. If in two cases out of three the fractures contain 70±5 per cent of fibrous component, the obtained temperature is taken to be T_{kb}.

3 SELECTION OF MATERIAL

3.1 GENERAL

3.1.1 The requirements of the present Section apply to steel for hull structures of FOP.

3.1.2 In general cases the selection of materials is performed in accordance with requirements of Part II "Hull" of MODU/FOP Rules and depending on the material design temperature T_d, criticality of the structural element in question, its thickness and conditions of loading: action of cyclic wind and ice loads, possibilities of dynamic mode of loading (under pressure of ice fields).

3.2. SELECTION OF STEEL GRADE

3.2.1 The steel grade (A, B, D, E, F) for thickness of 50 mm or less is selected from Table 1.5.1.2-1, Part II "Hull" of MODU/FOP Rules.

Application of steel for thicknesses not covered by the Table is only possible upon special agreement with the Register and on condition of meeting the requirements for viscosity and cold resistance properties determined by the Register in accordance with Table 1.5.1.2-2, Part II "Hull" of MODU/FOP Rules.

3.2.2 For steel of any grade with thickness exceeding 50 mm and steel of grade F with thickness exceeding the permissible value given in Table 1.5.1.2-1, Part II "Hull" of MODU/FOP Rules the results of tests for determination of crack resistance parameter CTOD and NDT are to be submitted. The CTOD tests are to be carried out at the specified design temperature or within the temperature range including the design temperature.

3.2.3 The values of CTOD parameter for the base metal and the HAZ metal of a welded joint at the design temperature T_d are not to be lower than those given in Tables 3.2.3-1 to 3.2.3-4 depending on the category of criticality of structural elements and conditions of their loading:

Table 3.2.3-1

Thickness, mm, not more than	Strength level (required minimum value of yield strength, MPa)									
	norm.	315	355	390	420	460	500	550	620	690
20	—	—	0,10	0,10	0,10	0,10	0,15	0,15	0,15	0,20
30	—	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
70	0,20	0,20	0,25	0,25	0,30	0,30	0,30	0,35	0,40	0,45

Table 3.2.3-2

Thickness, mm, not more than	Strength level (required minimum value of yield strength, MPa)									
	norm.	315	355	390	420	460	500	550	620	690
20	—	—	—	—	0,10	0,10	0,10	0,10	0,10	0,15
30	—	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
70	0,15	0,15	0,20	0,20	0,20	0,25	0,25	0,25	0,30	0,30

Table 3.2.3-3

Thickness, mm, not more than	Strength level (required minimum value of yield strength, MPa)									
	norm.	315	355	390	420	460	500	550	620	690
20	—	—	—	—	—	—	—	—	—	0,10
30	—	—	—	—	—	—	—	0,10	0,10	0,10
40	—	—	—	—	0,10	0,10	0,10	0,10	0,15	0,15
50	—	—	0,10	0,10	0,10	0,10	0,15	0,15	0,15	0,20
70	0,10	0,10	0,15	0,15	0,15	0,15	0,20	0,20	0,20	0,25

Table 3.2.3-4

Thickness, mm, not more than	Strength level (required minimum value of yield strength, MPa)									
	norm.	315	355	390	420	460	500	550	620	690
30			—	—	—	—	—	—	—	0,10
40	—	—	—	—	—	—	—	0,10	0,10	0,10
50	—	—	—	—	0,10	0,10	0,10	0,10	0,15	0,15
70	0,10	0,10	0,10	0,10	0,10	0,10	0,15	0,15	0,15	0,20

3.2.3.1 Special structures subjected to cyclic ice, wind and wave, and seismic loads.

The CTOD values for the base metal and for the HAZ metal are given in Tables 3.2.3-1 and 3.2.3-2, respectively.

3.2.3.2 Special structures statically loaded.

The CTOD values for the base metal and the HAZ metal are given in Table 3.2.3-3.

3.2.3.3 Primary structures subjected to cyclic ice, wind and wave, and seismic loads.

The CTOD values for the base metal and for the HAZ metal are given in Tables 3.2.3-2 and 3.2.3-3, respectively.

3.2.3.4 Primary structures statically loaded.

The CTOD values for the base metal and the HAZ metal are given in Table 3.2.3-4.

3.2.3.5 Secondary structures subjected to cyclic ice, wind and wave, and seismic loads.

The CTOD values for the base metal and the HAZ metal are given in Tables 3.2.3-3 and 3.2.3-4, respectively.

3.2.4 For the special structural elements directly subjected to dynamic ice or seismic loads, the values of nil ductility temperature (NDT) for the base metal with thickness t up to 40 mm are not to exceed:

T_d – for $t \leqslant 15$ mm;

T_d – 10°C for 15 mm $< t \leqslant$ 20 mm;

T_d – 20°C for 20 mm $< t \leqslant$ 30 mm;

T_d – 25°C for 30 mm $< t \leqslant$ 40 mm.

For metal with thickness exceeding 40 mm, the value of temperature T_{kb} corresponding to 70 per cent fibrous component in the fracture of a full-thickness specimen is not to be above $1{,}1T_d + 10$ °C.

3.2.5 For the special structural elements not covered by the requirement of 3.2.4 and the primary structural elements subjected to cyclic ice, wind and wave, and seismic loads, the values of nil ductility temperature (NDT) are not to exceed T_d when the thickness does not exceed 30 mm, and T_d – 10 °C for the metal with higher thickness.

4 ROLLED STOCK FOR STEEL STRUCTURES

4.1 GENERAL

4.1.1 Steels to be supervised by the Register is to meet the requirements of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, as well as requirements of the present Section.

The requirements for steels for members of FOP structural elements are identical to the requirements of Section 3.

The requirements of the present Section cover the weldable structural steels of normal and higher strength with thickness $\leqslant$100 mm and high-strength steel with thickness $\leqslant$70 mm.

The steel which does not satisfy the requirements of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and the requirements of the present Section with respect to chemical composition, heat treatment and mechanical properties can only be approved by the Register for use in the intended function after special consideration.

Subject to special consideration are also steels of Grades A40, D40, E40 and F40 with thickness exceeding 50 mm.

4.1.2 The steels to be supervised by the Register may have the following designations:

PC — a character placed before the grade designation to denote the fact that the steel is supplied under supervision of the Register;

W — a character indicating a steel of improved weldability, added before designation of steel grade;

S — a character added after designation of steel grade, if this steel, for some reason or other, does not fully meet the requirements of the Rules, but after special consideration was admitted for delivery;

Z — a character added to designation of steel grade in accordance with 3.14, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

4.1.3 Unless otherwise specified, the degree of plastic deformation in rolling is to be at least 5:1.

4.1.4 The rolled stock is to be submitted for inspection prior to application of a protective coating (if any).

The steel is to have no defects precluding its application for the intended purpose. The quantity, size and criteria of evaluation of the defects are to be agreed upon by the Register.

Repair of surface flaws by welding or other methods is to be carried out using a procedure approved preliminarily by the Register. In such cases the Register may demand appropriate testing and checking by non-destructive methods.

4.2 CHEMICAL COMPOSITION

4.2.1 The chemical composition of steel is to correspond to:

.1 the requirements of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships:

for steels of normal strength — 3.2.2 and Table 3.2.2-1;

for steels of higher strength — 3.2.2 and Table 3.2.2-2;

for steels of higher strength (grade F) — 3.5.2.2 and Table 3.5.2.2;

for high-strength steels — 3.13.2 and Table 3.13.2;

for steels with guaranteed properties throughout the thickness (Z-steel) — 3.14.2 and Table 3.14.2.1;

.2 the requirements of the present Part for the steel of improved weldability:

for steel of higher strength and improved weldability — Table 4.2.1.2;

Table 4.2.1.2

Grade	PCA32W PCD32W PCE32W PCF32W	PCA36W PCD36W PCE36W PCF36W	PCA40W PCD40W PCE40W PCF40W
Deoxidation	Killed, fine grain treated		
Chemical composition (ladle analysis), %			
C	0,8 – 0,12		
Si max	0,50		
Mn	0,60 – 1,60		
P max	0,010		
S max	0,008		
Cu max	0,35		
Cr max	0,20		
Ni max	0,40 (0,80 for Grade F steel)		
Mo max	0,08		
Al ac..sol, max	0,055		
Al total, max	0,06		
Nb max	0,05		
V max	0,10		
Ti max	0,05		
N max	0,009		
Sn max	0,02		
Sb max	0,10		
Pb max	0,005		
As max	0,02		
Bi max	0,005		
B max	0,0005		
Pcm max	0,22		

for high-strength steel of improved weldability — 4.2.2.

4.2.2 The chemical composition of higher strength steel of improved weldability is to comply with the requirements of Table 4.2.1.2.

The chemical composition of high strength steel of improved weldability is to meet the requirements of the standards and/or specifications approved by the Register.

Generally, the chemical composition of steel is to be subject to agreement with the Register during the initial approval of production.

The coefficient characterizing steel embrittlement due to structural transformations and determined by the formula

$$P_{cm} = \mathrm{C} + \mathrm{Si}/30 + (\mathrm{Mn} + \mathrm{Cu} + \mathrm{Cr})/20 + \mathrm{Ni}/60 + \mathrm{Mo}/15 + \mathrm{V}/10 + 5\mathrm{B},$$

is not to exceed: 0,22 for manganese and low-carbon steels and 0,29 for alloyed steels with Ni content $\geqslant 1,5$ per cent.

Sulphur and phosphorus content is to be limited to 0,01 and 0,015, respectively.

Steel is to be killed, fine grain treated. The nitrogen content may be up to 0,012 per cent provided that $\mathrm{Al/N} \leqslant 2$. Where the nitrogen content is in the range from 0,009 up to 0,012 inclusive, the Register may require additional ageing tests to be carried out in compliance with the requirements of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

4.2.3 Actual values of C_{eq} and P_{cm} are to be indicated in manufacturers' certificates covering the products delivered under supervision of the Register.

4.3 MECHANICAL PROPERTIES

4.3.1 The mechanical properties of steel are to comply with:

.1 the requirements of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships listed in:

3.2.3 and Table 3.2.2-1 — for steels of normal strength;

3.2.3, Table 3.2.2-2 and Table 3.2.3 — for higher strength steel;

3.5.2.3 and Table 3.5.2.3 — for higher strength steels (Grade F);

3.13.3, Table 3.13.3-1 and Table 3.13.3-2 — for high-strength steels;

3.14.3 — for steels with guaranteed properties throughout the thickness;

.2 the requirements of the present Part for steels with improved weldability.

In steels of higher and high strength with improved weldability the mechanical properties in tensile tests are to meet the requirements set out for respective Grades of steel without index "W". The values of impact in the impact bending tests are to be in compliance with Table 4.3.1.2.

Percentage reduction "Zz" of cross-section area (necking) in tensile testing of specimens made of steels of improved weldability and of higher and high strength, the longitudinal axis of which is perpendicular to the rolling surface is to be at least 35 per cent.

4.4 CONDITION OF SUPPLY

4.4.1 The supply condition of steel of both normal and improved weldability is to comply with the requirements of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships listed in:

3.2.4 and Table 3.2.4-1 — for steels of normal strength;

3.2.4 and Table 3.2.4-2 — for steels of higher strength;

3.5.2.4 — for higher strength steels of Grade F;

3.13.4 — for high-strength steels.

Table 4.3.1.2

Values of impact energy for steels of improved weldability and higher and high strength at impact bending test

Grade	Impact bending test temperature KVt (J), °C	Mean value of impact energy, KVt (J), min	Impact energy, KVt (J) per one specimen, min	Grade	Impact bending test temperature KVt (J), °C	Mean value of impact energy, KVt (J), min	Impact energy, KVt (J) per one specimen, min
PCA32W PCD32W PCE32W PCF32W	0 –20 –40 –60	44	31	PCD420W PCE420W PCF420W	–20 –40 –60	51	37
PCA36W PCD36W PCE36W PCF36W	0 –20 –40 –60	47	34	PCD460W PCE460W PCF460W	–20 –40 –60	55	39
PCA40W PCD40W PCE40W PCF40W	0 –20 –40 –60	50	36	PCD500W PCE500W PCF500W	–20 –40 –60	60	42

By agreement with the Register steels of normal and improved weldability and higher strength can be quenched and tempered.

4.5 SAMPLING

4.5.1 Unless there are some other directions, the sampling shall be carried out in accordance with the requirements of 3.2.5, 3.13.5 and 3.14.5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, depending on the steel grade and strength level.

4.5.1.1 The specimens for tensile testing are to be cut out in such a way that their longitudinal axes are perpendicular to the direction of last rolling (predominant direction of metal deformation), excluding the sections, rods and bars having width of 600 mm and less.

4.5.1.2 The specimens for impact bending tests are to be cut out having in mind the following considerations:

.1 for steels of normal weldability, normal and higher strength the longitudinal axis of specimens can be either parallel, or perpendicular to the direction of last rolling. As a rule, in acceptance rules at the stage of steel manufacture longitudinal specimens (KV_L) are used; at the same time, the manufacturer is to guarantee the value of impact performance specified for this steel and determined on transverse specimens (KV_T);

.2 for high-strength steel of improved weldability the impact bending tests, irrespective of the strength level, are carried out on transverse specimens;

.3 testing on both longitudinal and transverse specimens is required by the Register at initial tests of steel conducted with the purpose of granting to the firm the Recognition Certificate for Manufacturer, or when confirming this Certificate, if required so by the Register. When it appears necessary to demonstrate the guaranteed quality of rolled products in the course of acceptance testing, the Register may require combined impact bending tests on longitudinal and transverse specimens.

4.5.1.3 The specimens for tensile and impact bending tests are to be manufactured in accordance with requirements of 2.2, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

4.5.2 The samples and specimens for testing with the aim of determination of values CTOD, NDT and T_{kb} are to be manufactured in accordance with the requirements of 2.2.2, 2.3.2 and 2.4.2, respectively. As a rule, if this is required, the samples for testing in determination of crack resistance and cold resistance parameters are to be taken in places closest to places of taking samples for ordinary mechanical tests.

4.5.3 Unless otherwise specified, the samples are to be taken in the presence of a Register representative.

4.6 SCOPE OF TESTING

4.6.1 Rolled products are submitted for testing in batches. Each batch is to contain the products of one type, one melt and of the same as-delivered condition. The thickness and diameter of rolled products in the batch must not differ by more than 10 mm. As a rule, samples for testing are to be taken among products of the largest thickness and diameter in the batch.

4.6.2 Unless otherwise specified, the quantity of specimens selected for testing in the batch and the size of the batch are to comply with the requirements of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships:

for steels of normal and improved weldability, normal and higher strength — see 3.2.6;

for high-strength steels of normal and improved weldability — see 3.13.6 and 3.14.5.

4.6.3 The scope of testing for determination of CTOD, NDT and T_{kb} characteristics is specified in each separate case, taking into account the requirements of Section 2.

4.7 INSPECTION AND MARKING

4.7.1 The requirements for limiting deviations in thickness, quality of surface and its repair, also requirements for marking and sign system are to be in compliance with those contained in 1.4, 3.2.7 and 3.2.8, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

4.7.2 The steel is to have no defects impeding its use for the intended purpose.

The Manufacturer is to warrant the absence of surface defects and internal cavities (discontinuities) with dimensions preventing control of welds by non-destructive testing.

The steel plates for special structures are to be subjected to ultrasonic inspection.

The procedure and criteria for evaluation of inspection results are to be agreed upon by the Register.

4.7.3 Each semifinished product is to have legibly applied in a specified way and in the specified place the manufacturer's marking and Register brand.

The marking is to contain the following minimum information:

.1 name and/or designation of the manufacturer;

.2 steel grade in accordance with requirements of the present Part and Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships;

.3 batch No., cast No. or identification number in accordance with marking system of the manufacturer, permitting to trace the whole process of the semifinished product manufacture.

In delivery of rods and profiles in bundles it is permitted to have marking in tags.

4.8 DOCUMENTS

4.8.1 Each batch or semifinished product, if handled separately, after completion of testing is to be provided with a Register certificate or manufacturer's document certified by a Register representative. The certificate is to contain the following minimum of information:

.1 order number;

.2 construction project No., if known;

.3 name, number, dimensions and weight of semifinished products;

.4 grade (brand) of steel;

.5 batch or semifinished product number, or identification number permitting to identify the supplied material.

4.8.2 The mandatory supplement to the Register Certificate is to comprise the results of chemical analysis, mechanical tests and, if required, ultrasonic inspection confirming compliance of the material with the requirements of the Register (the supplement may be in the form of manufacturer's certificate and/or test records). Supply of steel with manufacturer's certificates, their form and contents are to be agreed upon separately with the Register and customer.

5 STEEL FOR BOILERS, HEAT EXCHANGERS AND PRESSURE VESSELS

5.1 GENERAL

5.1.1 This Section specifies the requirements for rolled steel intended for use in the construction of boilers, heat exchangers and pressure vessels, which are subject to supervision in accordance with the requirements of other parts of MODU/FOP Rules.

5.1.2 In general cases the steel for boilers, heat exchangers and pressure vessels is to satisfy the requirements of 3.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, or other technical documents.

5.1.3 The steel differing from that mentioned in 5.1.1 is to be recognized by the Register in accordance with 1.3.2.1, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

The alloyed steels are subject to special consideration by the Register.

5.1.4 The steel for boilers, heat exchangers and pressure vessels is to be manufactured under supervision of the Register by manufacturers recognized by the Register in accordance with 1.3.2, Part XIII

"Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

The scope of initial tests is to be defined in accordance with the requirements of Section 3.

5.1.5 At the initial survey for issue of Recognition Certificate for Manufacturer the positive results obtained in testing of shipbuilding hull steel, except for Grades A and B, may be extended to carbon and carbon-manganese boiler steel.

5.2 TESTING

5.2.1 In addition to 3.3, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, when conducting initial and acceptance tests of the steel the following requirements are to be taken into account.

5.2.1.1 The steel intended for manufacture of pressure vessels and liquified gas tanks is to be subjected to impact bending tests on specimens with sharp V-notch (KV_T) and longitudinal axis perpendicular to the direction of final rolling. For impact bending tests of profiles and strip steel longitudinal specimens (KV_L) may be selected.

Unless otherwise specified, impact bending tests of carbon and carbon-manganes steels intended for low-temperature use are to be carried out at a temperature of at least 5 °C lower than the design temperature.

In any case the mean value of impact KV_T for test pieces with section of 10×10 mm is to be not lower than 27 J and the mean value of impact KV_L not lower than 41 J.

Impact bending tests at a negative temperature may be required by the Register also for steels not intended for service at negative temperatures.

5.2.1.2 Steels with thickness above 10 mm intended for service at negative temperatures is to be subjected additionally to drop weight testing. The tests are to be performed on minimum two specimens selected from semifinished products of the largest thickness in each cast in accordance with the requirements of 2.2.6, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships. The test procedure is to be approved by the Register.

Absence of steel susceptibility to brittle fracture is to be confirmed at the temperature 5 °C lower than the design temperature.

6 STEEL TUBES AND PIPES

6.1 GENERAL

6.1.1 This Section specifies the requirements for steel tubes and pipes intended for welded structures, parts of machinery and equipment of MODU/FOP subject to the Register supervision in accordance with the requirements of other parts of MODU/FOP Rules.

6.1.2 The pipes and tubes subject to the Register supervision are to meet the requirements of 3.4, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

6.1.3 The pipes and tubes of various systems and pipelines intended for service at negative temperature are subject to special consideration by the Register.

6.1.4 The steel in pipes of welded elements of structures is to satisfy the requirements of Section 4.

7 STEEL FORGINGS AND CASTINGS

7.1 GENERAL

7.1.1 The present Section of the Rules covers steel castings and forgings intended for manufacture of machinery products and elements of structures, which are subject to the Register supervision in accordance with the requirements of other parts of MODU/FOP Rules.

7.1.2 The steel forgings and castings are to satisfy the requirements of 3.7 and 3.8, respectively, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

The forgings and castings intended for elements and products operating at negative temperatures are to meet the requirements of 3.5, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

The forgings and castings intended for elements of MODU and FOP are subject to special consideration by the Register. The requirements for material of forgings and castings, in this case, are established in accordance with the requirements of Section 3.

PART XIII. WELDING

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part of the Rules apply to welding of structural elements of MODU and FOP, subject to the Register supervision, and supplement the requirements of Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

1.1.2 The welded joints are to be executed in accordance with provisions of 1.3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships and MODU/FOP Rules following the approved by the Register technical documents and/or standards agreed with the Register.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 The definitions and explanations related to the general terminology are given in Part XIV "Welding " of the Rules for the Classification and Construction of Sea-Going Ships.

1.2.2 For the purpose of this Part the following definitions have been adopted.

Welding procedure specification (WPS) is a document compiled by the manufacturer of welding structures and containing all the necessary information on welding of particular joints, including specification for materials, welding method, edge preparation particulars and all technological parameters.

Note. The WPS based on the work experience and on recommendations of manufacturers of welding consumables and base metals, but lacking acknowledgement and approval, is called preliminary WPS (pWPS). Welding of specimens for approval of the technological process of welding is to be carried out in accordance with this preliminary WPS.

Welding procedure tests are the tests carried out under supervision and within the scope of requirements of the Register Rules to obtain confirmation of the manufacturer's ability to perform welding of particular joints in conditions close to actual conditions and in accordance with the WPS.

Pre-production welding test are the tests having the same function as a welding procedure tests, but based on a non-standard piece and samples simulating the production conditions.

Production tests are the tests, including destruction tests, based on welding of specimens obtained directly in the process of product manufacture and treated in the same way, as the products. Depending on particular conditions and possibilities, the specimens can be cut from allowance material of structures or can be manufactured as "witness specimens" in the same conditions, as actual products, following the same WPS.

Welding procedure approval record (WPAR) is a record comprising all relevant data from the welding of a test piece needed for approval a welding procedure specification as well as all results from the testing of the test weld.

WPAR include the following forms (records): Details of Weld Test and Test Results Report.

Welding Procedure Approval Test Certificate is a Register document confirming the fact that the technological process of welding employed at the shipyard or firm manufacturing welded structures has passed the tests and is approved by the Register for industrial application.

1.3 SCOPE OF SUPERVISION

1.3.1 For welding operations in construction of MODU and FOP the scope of supervision by the Register is determined in accordance with 1.4.2, Part XIV "Welding " of the Rules for the Classification and Construction of Sea-Going Ships, taking into account the requirements of the present Part.

1.4 TECHNICAL DOCUMENTATION

1.4.1 The technical documentation for welding to be submitted for coordination of the project of MODU or FOP construction as a whole is specified in Section 4, Part I "Classification" of MODU/FOP Rules. The technical documentation for structures which are subject to the Register supervision is to contain information on welding within the scope of requirements formulated in the parts of MODU/FOP Rules covering the structures mentioned above.

2 TECHNOLOGICAL REQUIREMENTS FOR PROCESSES OF MANUFACTURE OF WELDED STRUCTURES FOR MODU/FOP

2.1 GENERAL

2.1.1 All firms (shipyards, manufacturers of welded structures, welding facilities), which perform operations in welding of structures under supervision of the Register, are to prove the readiness to carry out work of the required level of complexity and to guarantee in full scope the fulfilment of requirements of the Register put forward in the present Part.

2.1.2 The readiness to carry out the welding operations means providing the welding facilities with all the required equipment, jigs and fixtures, functioning of an internal quality control system, the necessary level of production personnel skill, as well as meeting the requirements of the Register approval for technological processes of welding employed.

2.1.3 The firms are to must guarantee, through regular internal checks and inspections in the course of product manufacture and after completion of welding operations, that all the work is done in full compliance with the requirements of the Rules.

2.1.4 In case the firm employs for intended work outside subcontractors or casual workers, the responsibility for meeting the requirements concerning the production control lies, in accordance with 2.1.3, with the prime contractor.

2.1.5 In the general case, the requirements in quality control to be fulfilled by the contractor include checking of the following factors:

.1 base metals;

.2 welding consumables;

.3 edge preparation and assembling for welding;

.4 conditions of storage and procedure for issue of welding consumables;

.5 compliance of the conditions of work in assembly and welding with the requirements of the welding process specification;

.6 compliance of the welding and thermal treatment technology with the requirements of the welding process specification;

.7 compliance of welded joint dimensions with the requirements of design documentation;

.8 acceptance control and tests of welded joints and structures, as well as procedure for elimination of defects;

.9 compliance of the welders' skill with the nature and complexity of the work to be done.

2.1.6 The firms are to grant to the Register surveyors free access for performance of all necessary checks and surveys in the course of supervision over manufacture of welded structures.

In case the quality of welding operations does not meet all the established requirements, the Register syrveyor may demand stopping of all the work until elimination of the factors affecting negatively the quality of production.

2.2 TECHNOLOGICAL PROCESSES OF WELDING

2.2.1 General.

2.2.1.1 For welding of structures supervised by the Register only technological processes and welding methods may be used warranting high stability of guaranteed quality of welded joints, confirmed by the weld structure manufacturer by approval testing or other methods in accordance with the requirements of the Rules or by a separate agreement with the Register.

2.2.1.2 The document, which identifies unambiguously the technological process of welding employed by the manufacturer, is the Welding Procedure Specification (of the manufacturer) — WPS.

2.2.1.3 The consideration and procedure of approval by the Register of technological processes of welding is stipulated by the requirements of the present Part.

2.2.1.4 The technological processes of welding used by the manufacturer are to be permitted for application by the Register. Such permission is certified by a document stating that the welding process has passed the approval procedure: this is Welding Procedure Approval Test Certificate.

2.2.2 Approval of technological processes of welding.

2.2.2.1 The principal type of approval for technological processes of welding is conduction of approval tests. The approval tests may be standard, and the requirements for them are established in Section 6, Part XIV "Welding " of the Rules for the Classification and Construction of Sea-Going Ships, or they can be pre-production, before starting the production. Type of samples and arrangements for the pre-production tests are established for each particular case and are subject to special consideration by the Register. At the same time the pre-production tests conducted before starting the production are to be carried out observing the following main requirements:

.1 welding of samples is to be carried out in conditions which are as close as possible to welding of actual structures, with simulation of integrated effect of the factors influencing the quality of weld metal;

.2 in welding of samples the assembly fixtures, devices, positioners, etc. are to be similar to those used in production;

.3 the tack welds, if necessary, are to be tested as parts of the completed joint;

.4 the scope of sample checking includes visual examination and measurements, surface cracks control (magnetic particle inspection or dye penetrant testing), hardness testing, control of macrosections, also some types of destructive tests by agreement with the Register;

.5 the region of approval with respect to thickness of base metal and of employed welded joints is limited, as a rule, by thickness of particular assemblies simulated by the conducted tests.

2.2.2.2 Production tests are carried out by special demand of the Register in cases when there are some doubts about product quality stability, or changes in technological process parameters are suspected, or when the standard and preliminary tests are, in the Register opinion, insufficient for a particular technological process. Such technological processes, which are distinctive in higher degree of probability of deviations in quality of welded joints, include:

.1 vertical — downward welding;

.2 one-side welding with free back-forming of weld root using coated electrodes or flux-cored wire;

.3 welding methods with high heat input (electrogas welding, electroslag welding, etc.);

.4 welding methods extra-sensitive to assembly and edge preparation quality, such as electron beam and laser welding.

2.2.2.3 In separate cases the Register can decide to approve the technological processes of welding at a particular firm on the basis of previous experience of work with welding of similar structures without conduction of tests. This way of approval cannot be used for welding of special structures, for welding of high-strength steels and steels of high cold resistance, also for technological processes requiring preliminary or in-process tests.

2.3 PRODUCTION PERSONNEL. SKILL OF WELDERS

2.3.1 All operations in welding of structures of MODU and FOP to be supervised by the Register are to be carried out by qualified welders only, who have passed the required tests and have valid Welder Approval Test Certificates issued by the Register in accordance with provisions of Section 5, Part XIV "Welding " of the Rules for the Classification and Construction of Sea-Going Ships.

The nature and complexity of work performed by welders in working conditions is to be in full compliance with the area of approval indicated in the Welder Approval Test Certificates.

The possibility of admittance to work of welders having qualification certificates issued by other authorities, including classification societies, is a subject of a separate consideration by the Register. However, in any case the following requirements remain true:

.1 equivalency of scope and quality of qualification tests conducted for welders' certification to requirements of Section 5, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships;

.2 compliance of the admittance granting procedure with the requirements of Section 5, Part XIV "Welding " of the Rules for the Classification and Construction of Sea-Going Ships;

.3 compliance with the range of approval established in accordance with the requirements of Section 5, Part XIV "Welding " of the Rules for the Classification and Construction of Sea-Going Ships depending on the scope of practical tests at certification.

2.3.2 Each production department dealing with welding work is to have on its staff a responsible person, a surveyor engaged in direct supervision of proper observation of the requirements for welding operations in accordance with the documentation approved by the Register.

As a rule, the production welding supervisor is to have a qualification of a diploma engineer in welding. Among his duties is informing the Register surveyor of any changes in the technological processes of welding and of all deviations, if any of them took place in execution of welding operations.

The welding supervisor is personally responsible for timely and efficient execution of the following activities and control operations:

.1 drafting of WPS and certification of welding technological processes;

.2 control of welders' qualifications conformity with the requirement of the Register;

.3 incoming control of base metal and welding consumables;

.4 observation of conditions of welding consumables storage and issue, of its conformity with established requirements;

.5 edge preparation and assembly for welding;

.6 maintenance of the welding equipment, jigs and fixtures in proper technical condition;

.7 monitoring of welding operations to detect any deviations from the WPS;

.8 monitoring and analysis of welded joints quality on the basis of in-process and acceptance control;

.9 control and monitoring of work in repair of defects in portions of welded joints.

2.4 BASE METAL. WELDABILITY

2.4.1 The base metals employed in manufacture of welded structures of MODU and FOP supervised by the Register are to fully comply with the respective requirements of the Rules (see Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships and Part XII "Materials" of MODU/FOP Rules).

In view of this, the weldability of base metal is considered approved in the course of testing aimed at recognition by the Register of both the metal and its manufacturer.

Given below are general requirements stipulating the necessity for additional weldability tests, as employed in specific conditions of welded structures manufacture at various firms.

2.4.2 The additional weldability tests are conducted in the scope of testing for approval of welding technological processes and normally include:

.1 determination of heat affected zone properties for actual product manufacture cycle (in most cases it can be achieved using standard samples, as specified in Section 6, Part XIV "Welding " of the Rules for the Classification and Construction of Sea-Going Ships);

.2 confirmation of the welded joint resistance to cold cracking for specific conditions of welding operations (as a rule, this requires the use of non-standard, so-called "technological" or "laboratory" samples taken in the course of preliminary approval tests).

2.4.3 The necessity to conduct additional weldability tests is established by the requirements of the present section, as well as Section 6, Part XIV "Welding " of the Rules for the Classification and Construction of Sea-Going Ships and in general cases it is substantiated by the following factors:

.1 application of special welding methods, for instance, those requiring high heat input, which are not included into the normal range of approval on the basis of weldability test results;

.2 special requirements for weld and heat affected zone properties, such as defined by the results of crack resistance tests (CTOD);

.3 application of base metals highly sensitive to particular features of welding technological processes (including high-strength steels, microalloyed cold-resistant steels, high-alloyed steels of complex structure, etc.);

.4 welding in unfavourable conditions;

.5 heat treatment after welding.

2.5 WELDING CONSUMABLES

2.5.1 The welding consumables employed in welding of structural elements of MODU and FOP supervised by the Register are to be approved by the Register in accordance with the requirements of Section 4. At the same time, the use of welding consumables are to comply with instructions contained in their Type Approval Certificate, as well as requirements listed below.

2.5.2 In general cases, the employed welding consumables are to ensure equivalence of characteristics of welded joints and base metal quality.

The ultimate breaking strength of a welded joint is not to be below the ultimate breaking strength of steel employed for manufacture of the given structural element.

For the weld and heat affected zone metal the values of impact and test temperature are to comply with the requirements for welded joint serviceability.

2.5.3 The choice of welding consumables intended for welding of highly-loaded primary and special structures with thickness of 50 mm and above are to be based also on results of crack resistance testing in accordance with CTOD procedure at temperature specified in Part XII "Materials" of MODU/FOP Rules.

2.5.4 Selection of grade of welding consumables for welding of structures of normal and higher strength steels.

The welding consumables are to be used for welding of steel of those grades for which they were approved by the Register in accordance with Table 2.5.4.

Using the table, it is necessary to be guided by the following requirements:

.1 when producing welded joints where a steel of normal strength is welded with a steel of higher strength welding consumables can be used which correspond to the lowest grade permissible according to requirements of Table 2.5.4 for each steel taken separately (for instance, in a welded joint involving steels of grades D and E32 welding consumables of grade 3 may be used);

.2 when producing welded joints where steels of the same strength levels are welded, but with different requirements concerning impact bending test temperature, welding consumables can be used which correspond to the lowest grade permissible according to Table 2.5.4 for each steel taken separately, except for steel of grade E40 (for instance, in a welded joint involving steels of grades D32 and E32 welding consumables of grade 3Y can be used);

.3 when producing welded joints where steels of higher strength are welded, also when a higher

Table 2.5.4

Grade of welding consumables	Shipbuilding steel									
	normal strength				higher strength steel					
	A	B	D	E	A32, A36	D32, D36	E32, E36	A40	D40	E40
I,IS,IT,IM,ITM, IV	+	—	—	—	—	—	—	—	—	—
IY,IYS,IYT,IYM, IYTM, IYV	+	—	—	—	+[1]	—	—	—	—	—
2,2S,2T,2M,2TM,2V	+	+	—	—	—	—	—	—	—	—
2Y,2YS,2YT, 2YM, 2YTM,2YV	+	+	—	—	+	—	—	—	—	—
2Y40,2Y40S,2Y40T, 2Y40M, 2Y40TM, 2Y40V	See 2.5.4.4				+	—	—	+	—	—
3,3S,3T,3M,3TM,3V	+	+	+	—	—	—	—	—	—	—
3Y,3YS,3YT,3YM, 3YTM,3YV	+	+	+	—	+	+	—	—	—	—
3Y40,3Y40S,3Y40T, 3Y40M,3Y40TM, 3Y40V	See 2.5.4.4				+	+	—	+	+	—
4Y,4YS,4YT,4YM,4YTM, 4YV	+	+	+	+	+	+	+	—	—	—
4Y40,4Y40S,4Y40T, 4Y40M,4Y40TM,4YV	See 2.5.4.4				+	+	+	+	+	+

[1]See 2.5.4.5.

strength steel is welded with normal strength steel, welding consumables with controlled content of diffusible hydrogen, as specified in Table 4.2.1.4, Part XIV "Welding " of the Rules for the Classification and Construction of Sea-Going Ships, are to be used. But only electrodes with basic coating are permissible;

.4 for welding of normal strength steels (grades A, B, D, E) welding consumables approved for corresponding steel grades A40, D40, E40 may only be used with special permission of the Register for particular grades of welding consumables;

.5 use of grade 1Y welding consumables for welding of higher strength steels is allowed only for joints with thickness up to 25 mm inclusive;

.6 welding consumables selected from Table 2.5.4 can be also specified for welding of other steels, besides those covered by the table, if such steels in their mechanical properties and chemical composition are equivalent to steels for which the particular welding consumable has been approved;

.7 rutile-type electrodes may be used for welding of secondary structures from normal strength steel with thicknesses up to 20 mm and not subjected to dynamic loads;

.8 electrodes with oxide type coating are not permitted for use in construction of MODU and FOP.

2.5.5 Selection of welding consumable grade for welding of high-strength steel structures.

The welding consumables are to be used for welding of high-strength steels of grades, for which they are permitted by the Register, as specified by Tables 2.5.5-1 and 2.5.5-2.

Table 2.5.5-1

Identification of grades of welding consumables by test temperature	Identification of grades of high-strength steels by impact bend test temperature			
	A(420/690)	D(420/690)	E(420/690)	F(420/690)
3Y(42/69)	+	+	—	—
4Y(42/69)	+	+	+	—
5Y(42/69)	+	+	+	+

Table 2.5.5-2

Identification of grades of welding consumables by strength level	Identification of grades of high-strength steels by strength level					
	(A/F) 420	(A/F) 460	(A/F) 500	(A/F) 550	(A/F) 620	(A/F) 690
(3Y/5Y)42	+	—	—	—	—	—
(3Y/5Y)46	+	+	—	—	—	—
(3Y/5Y)50	+	+	+	—	—	—
(3Y/5Y)55	—	—	+	+	—	—
(3Y/5Y)62	—	—	—	+	+	—
(3Y/5Y)69	—	—	—	—	+	+

In selection of grades the following limitations and requirements are to be kept in mind:

.1 in some cases the Register may limit the scope of application of a particular grade of welding consumables to just one strength grade of base metal without expanding the approval to the lowest grades of high-strength steel in accordance with Table 2.5.5-2;

.2 when joining high-strength steel to the same and also joining high-strength steel to higher or normal strength steels it is necessary to apply welding consumables with controlled content of diffusible hydrogen and having classification indices HHH or HH in accordance with Table 4.2.1.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships;

.3 it is not recommended to use a single-run and two-run welding for joints in high-strength steels. They may only be approved by the Register on the basis of additional tests conducted to a special program agreed with the Register;

.4 it is not recommended to use electrogas and electroslag welding technologies for joints in high-strength steels. They may only be approved by the Register on the basis of additional tests conducted to a special program agreed with the Register;

.5 it is not recommended to use multi-arc and one-side welding with various types of backing for joints in high-strength steels. They may only be approved by the Register on the basis of additional tests conducted to a special program agreed with the Register;

.6 electrodes with rutile and iron oxide type of coating are not to be applied for welding of high-strength steel structures;

.7 application of welding consumables of all grades subjected to testing within the scope specified in 4.6, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships, for welding of high-strength steels is only possible for joints with base metal thickness not exceeding 70 mm. The problem of use of welding consumables for welding of steels exceeding 70 mm in thickness is a subject to special consideration by the Register and requires additional testing to a program agreed upon specially by the Register in accordance with provisions of 4.2.

2.5.6 Selection of welding consumable grade for welding of shipbuilding steel structures operating at low temperatures.

Welding consumables for welding of structures of shipbuilding steel grades F32, F36 and F40 operating at low temperatures are to be used in accordance with requirements of Table 2.5.6.

Table 2.5.6

Welding consumable grade	Shipbuilding steel grade		
	F32	F36	F40
5Y,5YS,5YT, 5YTM,5YV	+	+	—
5Y40,5Y40S,5Y40T,5Y40M, 5Y40TM,5Y40V	+	+	+
5Y42,5Y42S,5Y42M	—	+	+
5Y46,5Y46S,5Y46M	+[1]	+[1]	+

[1]Use of welding consumables of grade 5Y46 intended for welding of high-strength steels is to be agreed upon additionally by the Register.

The welded joints where the higher strength steel with the index F is welded to the steels of other grades, the grade of welding consumables is to be selected according to the requirements of 2.5.4.

2.6 TYPES OF WELDS IN WELDED JOINTS. GENERAL RECOMMENDATIONS

2.6.1 Butt joints.

2.6.1.1 Depending on the thickness of elements to be joined, method and spatial position of welding and ease of access for welding, the butt joints can be produced without edge preparation, with one-side or two-side (symmetrical or asymmetrical) groove, as required by national standards. In cases when the designer or manufacturer of welded structures selects a non-standard form of edge preparation and design dimensions of the welded joint, these are to be indicated separately in the drawings and in the specification for welding operations.

The shape of welds and details of edge preparation for special welding methods (for instance, one-side welding on copper slides, gas electric or electroslag welding) are to be approved by the Register individually on the basis of welding technological process test results.

2.6.1.2 Butt welded joints are executed, as a rule, with full penetration in a technological process including operations of weld root dressing and back welding. Other methods of one-side welding can be used, which permit to omit operations of weld root dressing and backing. All parameters of such one-side welding technological process are to be minutely confirmed by approval testing. The scope of testing and quantity of samples in such cases are to be agreed upon additionally by the Register.

2.6.1.3 If the requirements and recommendations mentioned in 2.6.1.2 cannot be satisfied (for example, in case of one-side access to the weld), it is permissible to make one-side butt joints on the permanent backing or one-side lock joints. In this case the value of root gap is to be specified to ensure the guaranteed penetration and absence of defects, it is recommended to decrease the angle of bevel in comparison with ordinarily employed values.

The given type of joint is not to be used in special structural members, and as for primary members, the possibility of its use is to be considered separately by the Register, taking into account the requirements to ensure the fatigue strength.

2.6.1.4 The recommended forms of edge preparation for butt joints in clad steels are shown in Fig. 2.6.1.4.

2.6.2 Fillet, tee and cruciform joints with guaranteed full penetration.

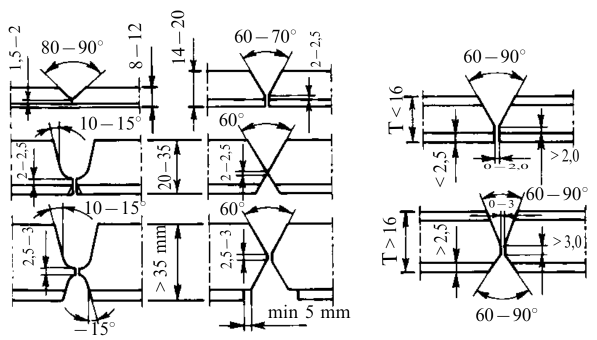


Fig. 2.6.1.4

2.6.2.1 Depending on thickness of members to be joined, method of welding, spatial position, as well as ease of access, fillet, tee and cruciform joints with guaranteed full penetration are effected with single or double bevel edge preparation. Design elements of edge preparation and dimensions of welds are selected in accordance with the requirements of national standards for respective welding methods. If non-standard forms of edge preparation or special requirements for weld shape are stipulated, they are to be indicated separately in the drawings and in the specification for welding operations.

2.6.2.2 As a rule, welds with guaranteed full penetration require weld root dressing and back welding. For welding methods allowing to omit these operations (electrodes for root weld backing, various types of flexible backups, etc.) all parameters of the technology, including design elements of edge preparation, are subject to separate confirmation by means of approval testing of technological welding processes.

2.6.2.3 If a fillet joint is to be flush (without extended free edge), for equivalent joints of special members a two-side asymmetrical edge bevel is to be selected, as shown in Fig. 2.6.2.3-1. At the same time, to prevent lamellar fracture of the base metal the edge bevel angle is to be increased in the direction away from the theoretical line of plate alignment.

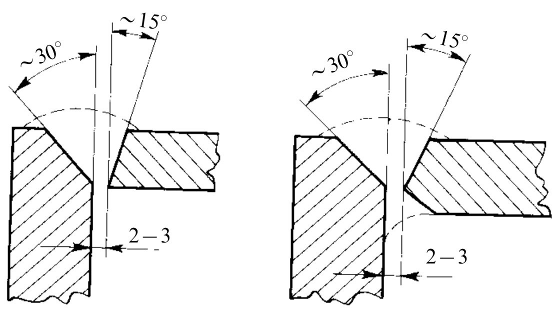


Fig. 2.6.2.3-1

Similar edge preparation are to be used in tee-type erection joints (or cruciform joints without extension of the continuous plate), where the element abutting at an angle is placed between the adjoining elements (Fig. 2.6.2.3-2).

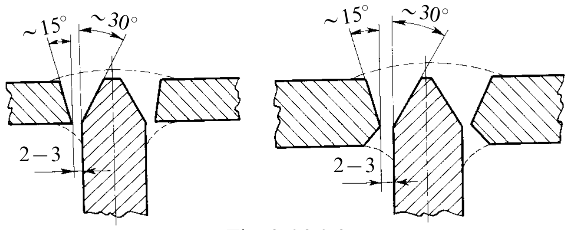


Fig. 2.6.2.3-2

2.6.2.4 Fillet, tee and cruciform joints which have access for welding from one side only can be prepared with one-side bevel of edges on the permanent backing. In this case the limitations and recommendations listed in 2.6.1.3 are to be taken into consideration.

2.6.3 Fillet, tee and cruciform joints with non-guaranteed full penetration.

2.6.3.1 This type of welded joints in the shape of edge preparation is identical to joints mentioned in 2.6.2 but differing from them by presence of permissible incomplete fusion f of the welded joint (Fig. 2.6.3.1). The technology of making joints with non-guaranteed penetration does not include the operation of root dressing before back welding, which could result in incomplete fusion.

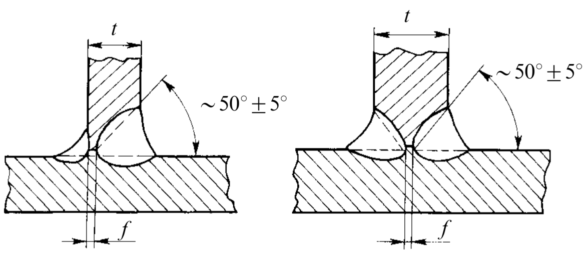


Fig. 2.6.3.1
Examples of two-side tee joint with full non-guaranteed penetration for one- and two-side edge bevel at the abutting plate

2.6.3.2 In normal practice incomplete fusion of weld root is limited to value of $f \leqslant 0{,}2t$ (not exceeding 3 mm), where t is the thickness of abutting plate (with edge preparation). The effective thickness of the weld in this case is taken to be equal to the thickness t of the abutting plate, and the incomplete fusion f is to be compensated by additional increase in height of fillet welds a by a value not lower than f for each side of the joint.

2.6.3.3 The joints with non-guaranteed full penetration are not to be used is special structures, and as for primary structures, the possibility of use in them is subject to special consideration by the Register, with due regard to the fatigue strength requirements. In any case, the issue of application in a structure of joints with non-guaranteed full penetration can be accepted for consideration by the Register only if the manufacturer can submit confirmed guarantees, that value f was properly controlled by nondestructive method both in the process of manufacture and at the acceptance of the joints.

2.6.3.4 The one-side joints with non-guaranteed full penetration and without back welding (Fig. 2.6.3.4) are not to be used in special and primary structures (members).

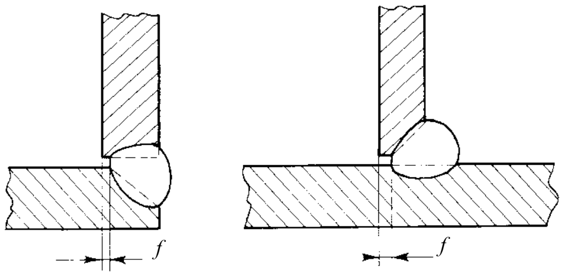


Fig. 2.6.3.4
Examples of one-side fillet and tee joints with non-guaranteed full penetration

The issue of the possibility of such joints use in secondary structures is to be considered by the Register, as specified in 2.6.3.3.

Note. This limitation has no force for joints completed with the use of specialized welding methods and welding consumables intended for one-side welding. Incomplete fusion in this case is called shrinkage of one-side weld and its value is normally limited to $f \leqslant 0{,}05t$ but is not to exceed 1,0 mm (simultaneously limitations are introduced in the extent of a single defect and in summary length of defects per 1 m of weld).

2.6.4 Fillet, tee and cruciform joints with edge preparation and designed lack of fusion.

2.6.4.1 Joints with designed lack of fusion (Fig. 2.6.4.1) have a specific feature: the edge bevel covers only a part of the abutting plate thickness. As a result of this, in the weld root after completion of welding a lack of fusion appears with nominal value $d=c+f$, where c is the value of designed lack of fusion in the weld root taken to be equal to the value of root face; f is the value of permissible incomplete fusion in the weld root resulting from omitted operations of dressing and back welding.

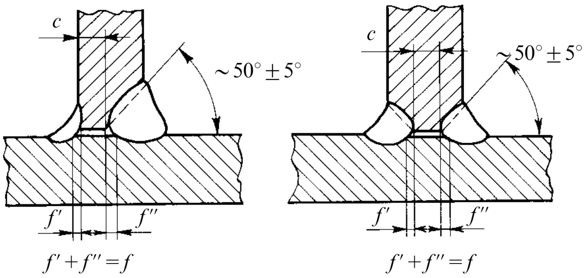


Fig. 2.6.4.1
Examples of two-side tee joints with designed lack of penetration

The design elements of edge preparation, weld dimensions and joint characteristics c, d and f are to be indicated in the drawings and in the specification for welding operations (an example is given in Fig. 2.6.4.1).

2.6.4.2 Incomplete fusion of the weld root is limited by value $f \leqslant 0{,}02t$, but it is not to exceed 3,0 mm, and the value of c is not, as a rule, to exceed $1/3t$. For the given type of joints the effective thickness of the fillet weld is taken to be equal to the thickness of the abutting plate t minus nominal lack of penetration $d=c+f$.

2.6.4.3 Application of joints with designed lack of penetration is limited to two-side type and is subject to special consideration by the Register.

Another limitation is the use of such joints only in the primary and secondary structures not subjected to considerable dynamic and fatigue loads. The manufacturer is to guarantee, by means of proper acceptance control, the compliance of actual and design values of parameter d, as well as acceptable level of defects in fillet weld cross-section.

2.6.5 Fillet, tee and cruciform joints executed by fillet welding without edge preparation.

2.6.5.1 The joints achieved by fillet welding without edge preparation are to be employed, as a rule, in structures two-side version. Application of joints with one-side fillet welds (for example, in box girders of closed profile) is subject to special consideration by the Register.

Design height of fillet welds a is to be determined in accordance with 1.7, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships.

2.6.5.2 Depending on the penetration in the fillet weld root two types of joint are differentiated: with normal and with deep penetration. In the latter case penetration of the weld metal into the base metal is much deeper than the theoretical point of weld root (Fig. 2.6.5.2) which fact, in meeting of certain requirements, may be taken into account in calculation of the fillet weld height a.

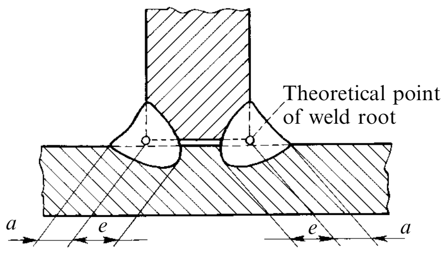


Fig. 2.6.5.2
T-joint formed with two-side fillet welding with deep penetration

2.6.5.3 Application and approval of welding technological processes ensuring formation of fillet welds with deep penetration is a subject for separate consideration by the Register.

In case of successful results of tests for approval of technological processes the Register may permit to define the design value of thickness a_d of a fillet weld with deep penetration using equation (Fig. 2.6.5.2):

$$a_d = a + 2e_{min}/3 \quad (2.6.5.3)$$

where a = design height of fillet weld defined by weld reinforcement dimensions (counting from the theoretical point of the root);

e_{min} = minimum penetration depth established individually on the basis of tests for approval of welding technological processes.

2.6.5.4 Permissible deviations from the theoretical shape and design dimensions of fillet welds are to correspond to the requirements of national standards or other regulating documents and must be indicated in the documentation for welding to be approved by the Register.

2.7 WELDING OF HULLS AND EQUIPMENT OF MODU AND FOP

2.7.1 Requirements for preparation of joints for welding.

2.7.1.1 Workpieces for assembly of joints to be welded are to be properly machined, straightened and must have inambiguous identification in accordance with the requirements of technical documentation for manufacture of welded structures.

2.7.1.2 The applied cutting methods and equipment are to ensure compliance of dimensions and surface finish of parts prepared for welding with the requirements stated in the documentation approved by the Register.

2.7.1.3 Additional dressing of edges and surfaces of parts to be welded by mechanical methods after thermal cutting or for removal of protective coatings are to be carried out prior to assembling in cases when it is stipulated in the welding procedure specification, in accordance with the requirements of the present Section and also of the technical documentation for manufacture of welded structures.

2.7.1.4 Surfaces of parts and structures to be welded are to be clean and dry. The mill scale, rust, dross remaining after thermal cutting, burrs, oils, paint and dirt are to be carefully removed prior to welding.

The quality of cleaning of the edges for welding is to be controlled and approved by the authorized representative of the manufacturer.

2.7.1.5 It is permissible to carry out welding of steel parts coated with protective shop primer without removal of the latter, if the following requirements are satisfied:

.1 the shop primer has been subjected to appropriate tests and has been approved for application by the Register;

.2 the manufacturer using a protective shop primer is to guarantee and confirm by control checks the fact that the primer application conditions stated in the Type Approval Certificate remain valid, and in welding (especially fillet welding) there is no excessive pore formation affecting negatively the quality of welds;

.3 there are no additional limitations for application of protective primers not removed before welding according to the requirements of the present Section or documentation approved by the Register.

N o t e s: 1. For fully mechanized processes of two-side fillet welding (for instance, in the line for group welding of framing to plating) the permission for welding without prior removal of protective primer, provided the Type Approval Certificate is available, may be granted by the Register only after special procedure of testing directly at the plant (at the welding structures manufacturer).

2. The control checks performed in the course of manufacture of structures are to include measuring of coating thickness on witnessing specimens, also welding of T-joints for evaluation of the tendency to pore-formation by fracture testing.

2.7.1.6 The gap between the joint of parts assembled for welding is to correspond to regulating requirements (tolerances) indicated in the Welding Procedure Specification and/or technical documentation approved by the Register.

2.7.1.7 It is allowed, with preliminary permission of the Register surveyor, to correct too large gaps by deposition, if the deviation from the acceptable rated value of the gap (excluding the tolerance) does not exceed the lowest thickness of the abutting elements and is not higher than 10 mm. Correction of the unacceptable gaps by deposition is allowed at a length not exceeding 500 mm per 1 m of weld and the total length of corrected portions is not to exceed 30 per cent of the length of technologically self-dependent welded joint. When the length of joint is less than 500 mm the deposition may be made over the whole length of the joint.

N o t e s: 1. The portions corrected by deposition are to be accepted by an authorized representative of the plant and after that submitted to the Register surveyor.

2. In case of semiautomatic and manual welding it is permissible to use, instead of deposition over the whole width of the edge, single beads ("crests"). In a T-joint deposition may be made to any of the matching parts.

3. In case of automatic welding and fully mechanized methods of welding the joint portions corrected by deposition are to be dressed with grinding wheel or machined with cutting tools to fully restore the initial shape of edge preparation.

2.7.1.8 The welded edges corrected by deposition in accordance with directions of 2.7.1.7 are to be checked by visual examination and measurement and, if necessary, by suitable non-destructive methods. In this case the Register surveyor may specify additional portions for weld control in places with gaps corrected by deposition.

2.7.1.9 In places, where large gaps have been corrected by deposition, the width of weld reinforcement or fillet weld calibre is to be increased by the summary height of deposit, with the reinforcement height remaining the same. The deposit height at the edge end face is to be measured parallel to the part surface.

2.7.1.10 By a special permission of the Register surveyor the gaps, which exceed several times the dimensions given in 2.7.1.7, can be corrected by welding — in a strip of plate with width of at least 10 times larger than the thickness of parts to be joined but not less than 200 mm (see Fig. 2.7.1.10 (*c*)).

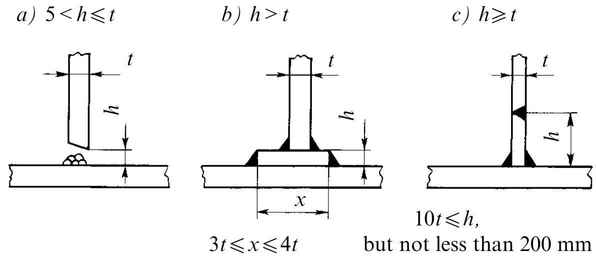


Fig. 2.7.1.10
Patterns for elimination of inadmissible gaps in T-joints:
a) by deposition; *b*) by insertion of compensating strip;
c) by welding-in of additional strip

For special members correction of too large gaps by using versions Fig. 2.7.1.10 (*b*) and Fig. 2.7.1.10 (*c*) is not permitted.

Note: For T-joints made by fillet welding without edge preparation (calibre), when the gap size is only slightly larger than the value indicated in Fig. 2.7.1.7, the correction of the gap may be done by welding onto the main part of a compensating lap strip with width $3t\leqslant x\leqslant t$, where t is the thickness of the abutting part (Fig. 2.7.1.10 (*b*)).

2.7.1.11 When assembling structures to be welded special attention is to be given to ensuring the planeness of the structures and alignment of the joint edges to be welded.

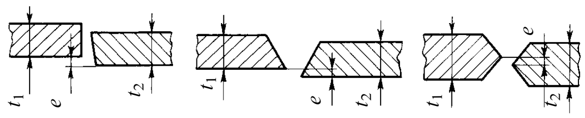


Fig. 2.7.1.11-1
Acceptable misalignment of parts in butt joints:
$e\leqslant 0{,}1t_{min}$, but not more than 2,0 mm for special and primary structures;
$e\leqslant 0{,}15t_{min}$, but not more than 3,0 mm for secondary structures

It is considered acceptable for butt joints to have root misalignment e (or misalignment of part edges, when there is no edge preparation) of value $e\leqslant 0{,}1t$ not exceeding 2 mm, where t is the minimum thickness of parts to be joined. For thicknesses above 20 mm it is permissible to have root misalignment up to 3 mm with extension of not more than 300 mm per 1 m of weld length.

For cruciform joints the acceptable misalignment of parts to be joined is to be corresponding to values indicated in Fig. 2.7.1.11-2. For control of alignment it is permitted to drill control holes in transverse members, which are to be welded over afterwards.

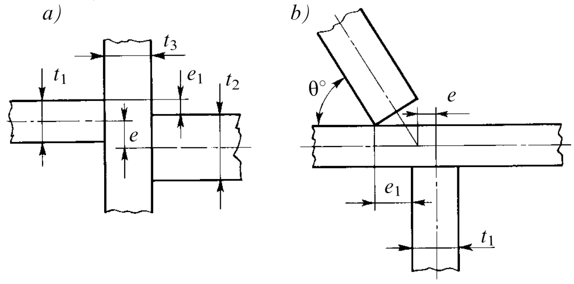


Fig. 2.7.1.11-2
Acceptable misalignment of parts in cruciform joints
a) For assemblies with angle of mating from 90° to 75°:
$e\leqslant 0{,}1t_{min}/3$ and $e_1\leqslant(5t_{min}-3t_{max})/6$
— for special and primary structures;
$e\leqslant t_{min}/2$ and $e_1\leqslant(2t_{min}-t_{max})/6$
— for secondary structures;
b) For assemblies with angle of mating less than 75°:
$e\leqslant t_1/3$ — for special and primary structures;
$e\leqslant t_1/2$ — for secondary structures

2.7.1.12 When assembling the structures for welding the parts are to be fastened in special assembly jigs or with the use of elastic fasteners (thread chasers, cramps, turnbuckles, etc.), or with rigid fasteners (tack welds).

The use of temporary assembly jigs and tack welding is to be limited to minimum. The work in mounting of temporary assembly jigs and tack welding is to be performed by workers specially trained for the task and having certificates of approval for the required welding method.

Note. In cases, when the assembly tack welds are not to be removed and are not fully remelted in the principal weld (for instance, in manual welding with coated electrodes or in semi-automatic gas-shielded welding), the requirements for qualification of workers performing the tack welding in welded joints with full penetration are similar to requirements for welders approved by the Register.

2.7.1.13 The work in mounting of temporary assembly jigs and in tack welding is to be carried out using the welding consumables approved by the Register for welding of the structures in question. The conditions of welding operations (such as preheating or drying of edges), as well as welding duties are to correspond to requirements of respective welding process specifications for similar structures.

N o t e . For tack welding on special and primary structures of higher strength steels it is recommended and for structures of high-strength steels it is mandatory to have welding process specifications for such operations with approval by the Register according to the established procedure.

2.7.1.14 In the joints assembled for welding the tack welds are not to be placed on the side of backing.

At intersections of welds the tacks are not to be located at a distance less than 50 mm from the weld completed first.

It is not permitted to mount temporary fastening and leveling jigs on the surface of parts and braces subjected to high stresses (special structures and areas of structural stress concentration in primary structures). For this case it is recommended to use mechanical clamps and other fixtures not requiring tack welding.

2.7.1.15 The tack welds are to be cleaned from slag, metal splatter, examined visually. If the quality of tack welds does not satisfy the requirements for joints to be welded, the tacks are to be removed before execution of the principal weld. Tack welds with cracks are in no case be retained for subsequent welding and are to be removed without fail.

N o t e . In cases when the tacks are fully remelted in the course of principal weld formation (for instance, in case of automatic submerged arc welding), also in two-side welding of butt or tee joints in which the weld root is subjected to gouging on the tack side (see 2.7.1.14), some non-dangerous defects may be permitted in the tack weld metal, such as extra porosity or cuts.

2.7.1.16 In automatic submerged arc welding of butt joints, also in the use of other welding methods highly susceptible to formation of crater and other defects at the beginning and at the end of the weld outlet bars are to be used preventing damage to base metal, as required by 2.7.4.11.

2.7.1.17 Structures and products assembled for welding are to be checked and accepted by the quality control department of the plant (yard), after which submitted to the Register surveyor for examination.

2.7.1.18 Before welding of thick plate structures, especially those manufactured of alloyed high-strength steels, with closed section, it is recommended to check the presence of magnetic fields. For normal welding process the magnetic intensity is not to exceed 790 A/m for manual arc welding, 950 A/m for semi-automatic gas-shielded arc welding and 1400 A/m for automatic submerged arc welding. Structures with magnetic intensity exceeding the above values are to be subjected to demagnetization.

2.7.1.19 After completion of welding the temporary fastening and leveling fixtures are to be removed by methods excluding damage to base metal. In case of cuts-through and other damages to the base metal resulting from removal of temporary fastening fixtures they are to be eliminated by welding-up and dressing, providing smooth transition to the base metal.

The decrease or increase in thickness of the base metal after dressing are not to exceed the permissible deviations in plate thickness specified in 3.2.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

N o t e . Subject to complete removal with subsequent dressing to base metal are remains of the fastening fixtures welds on special and primary structures. On other structures the tack welds up to 10 mm in height may be left without dressing, if the latter is not specified in the technical documentation.

2.7.2 Welding in open-air sites and at low temperatures.

2.7.2.1 Welding of structures is to be performed, whenever possible, at indoor premises heated in winter time. If it is necessary to carry out such work in open sites, measures are to be taken to protect the welding zone against wind, moisture and cold.

In gas-shielded arc welding special attention is to be given to protection of gas shielding against wind and draughts. As a rule, reliable gas shielding may be ensured, if the velocity of air flows in the welding zone does not exceed 0,5 m/s.

Technological processes of gas-shielded arc welding allowing high-quality welding at larger velocities of air flows need additional approval of the Register with respect to this parameter.

2.7.2.2 When working in the open air under unfavorable weather conditions it is recommended to always dry the edges to be welded by preheating.

2.7.2.3 If the welding of structures is performed at sub-zero temperatures, measures are to be taken which will guarantee satisfactory quality of welds. Such measures, depending on the type of welded metal, its thickness and other factors (see 2.7.2.5) may include:

.1 checking and cleaning of edges to be welded from snow, hoar-frost and ice;

.2 drying of edges to be welded by heating to at least 20 °C;

.3 local preheating of edges to be welded before starting of welding;

.4 use of heat insulation devices;

.5 use of techniques ensuring higher temperature between runs in the process of welding (such as execution of one weld by several welders simultaneously, in the so-called block method, etc.).

Selection of particular techniques for welding at sub-zero temperature is made by the manufacturer and is agreed with the Register in the course of welding procedure approval.

2.7.2.4 The appropriate quality of welded joints may be achieved, if welding and associated operations on structures supervised by the Register and made of shipbuilding steels of normal and higher strength with thicknesses up to 20 mm inclusive are carried out at ambient air temperatures down to minus 25 °C, provided the welding consumables have been tested at such temperature in accordance with requirements of 4.2.2.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships. Otherwise, the lowest permissible welding temperature without preheating is to be determined according to the standards specified in the recom-mendations of manufacturers of the base metal and welding consumables and is to be agreed with the Register on the basis of the tests conducted for approval of technological welding processes.

Heating of part edges on a width of 100 mm on both sides of the weld to at least 20 °C is to be effected prior to welding in the following cases and at following temperatures:

.1 below minus 15 °C for forgings and castings used in the ship hull;

.2 below minus 10 °C for parts of joints made of semikilled steel.

The heating is to be fulfilled on the joint side to be welded first.

2.7.2.5 If in the course of welding the temperature falls below the value indicated in 2.7.2.4 the work in welding of joints is to be stopped after filling of the gap on one side of the joint and completion of a backing weld or the first seam on the other side of the joint. Prior to welding after a break in the work, a repeated heating or edge drying is to be carried out, if necessary, in accordance with requirements of 2.7.2.3, 2.7.2.4.

2.7.2.6 Thermal gouging and tack welding is to be carried out at the same air temperatures, which are permissible for welding of the above structures.

2.7.3 Preheating and heat treatment.

2.7.3.1 The necessity of and temperature of preheating before welding, as well as minimum temperature between runs are to be specified taking into account the following main factors:

.1 chemical composition of base metal and weld metal;

.2 thickness of parts to be welded and type of joint;

.3 welding technique and conditions (heat input);

.4 level and distribution of working and residual stresses in the structure;

.5 dependence of weld metal and heat affected zone properties on temperature;

.6 content of diffusive hydrogen in weld metal.

2.7.3.2 As a rule, in welding operations on structures made of normal and higher strength shipbuilding steels there is no need for preheating and control of temperature betweens runs in the process of welding. But the possibility of welding without preheat and/or control of temperature betweens runs for the above materials is to be agreed with the Register in the following cases:

.1 welding of higher strength steel structures with thicknesses exceeding 30 mm at below-zero temperatures;

.2 welding of higher strength steel structures at thickness of edges to be welded equal to 50 mm and above at any temperatures of ambient air;

.3 welding of tee joints in steels of higher strength with thicknesses of 20 mm and above using single-run fillet welds (calibre) at below-zero temperatures;

.4 welding of massive products and structures with high level of residual stresses with the use of welding consumables with high content of diffusive hydrogen (at the level of index H, see 4.2.1.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships);

.5 when there are special claims laid to the heat affected zone properties, which cannot be realized without preheating and/or control of temperature between runs (limiting of maximum hardness, setting of CTOD characteristic).

2.7.3.3 In manufacture of structures made of high-strength steels meeting the requirements of 3.13, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships the temperatures for welding operations (including the minimum permissible temperature for the work, necessity for and temperature of preheating, temperatures between runs, the necessity for and parameters of additional heating and post-heating) are set out in accordance with directions of 2.8.16 and are a subject to special consideration by the Register. At the same time, in cases listed below, permission of the Register for application of the technology for welding of high-strength steels without preheating requires mandatory conduction of tests in accordance with a separate program:

.1 welding in open-air sites;

.2 welding at ambient air temperatures below +5 °C;

.3 welding of steels of strength grades (A/F) 550 and above at any ambient air temperature;

.4 welding of products with thickness of edges to be welded above 70 mm;

.5 use of welding consumables with diffusible hydrogen level above 5 ml/100 g of weld metal (index HHH, see 4.3.2.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships).

The program of such testing is to include evaluation of tendency to cold cracking with the use of appropriate laboratory and/or technological samples, as well as welding of experimental structures or full-size models.

2.7.3.4 In welding of shipbuilding steels of higher and high strength grades up to (A/F) 550 inclusive the preheating may be effected by local heating up to the required part edge temperature at a width from 75 to 100 mm on both sides of the weld.

For high-strength structural steels of strength grades from (A/F) 620 to (A/F) 690 inclusive, especially at thicknesses above 50 mm, the method of preheating and method of maintaining the minimum temperature between runs are specified individually and are to be agreed with the Register in each particular case. In so doing, for massive products with large amount of welding work the Register may require general preheating for the whole part.

2.7.3.5 If the technology of welding work envisages the use of preheating and control of temperature between runs, their parameters are to be kept constant by appropriate means, the temperature is to be monitored and recorded in the process of welding operation. The instruments employed for temperature measurements are to ensure the required accuracy.

2.7.3.6 In welding of hull structures the heat treatment after welding are to be used when it is necessary to eliminate residual stresses. The heat treatment conditions are specified by the manufacturer of welded structures of by the designer on the basis of standards taking into account the recommendations or limitations of the base metal manufacturers. The Register approves the suggested heat treatment conditions on the basis of tests conducted for approval of welding technological processes.

2.7.3.7 The equipment and technical facilities employed for heat treatment of structures are to ensure uniform heating and are to be provided with instruments regulating the speed of heating and cooling of the workpiece, for maintaining the temperature within the specified limits. The parameters of heat treatment for each product are to be properly controlled and recorded.

2.7.3.8 If the dimensions of the structure are too large to heat treat the latter as a whole, it can be heat treated in parts in separate chambers. The technical facilities and procedure for heat treatment are to be considered by the Register in each particular case.

2.7.4 General requirements for welding operations.

2.7.4.1 The welding of structures and other products is to be carried out in accordance with the requirements of the drawings and respective welding process specifications approved by the Register.

2.7.4.2 In designing and manufacturing of welded structures a possibility is to be provided for welding in optimum spatial positions from the point of view of quality and ease of access.

2.7.4.3 Welding procedure used in production, as well as procedure control and monitoring, are to ensure high stability of the quality of welded joints in actual production conditions. To achieve this, the Register may require from the manufacturer of welded structures additional proofs of stability of welded joints quality for technological processes with higher degree of risk (see 2.2.3). As such proofs, the results of in-process may be used, also additional portions of weld can be assigned for non-destructive testing, as required by the Register surveyor.

2.7.4.4 For especially critical structures (special members, also primary members, as selected by agreement between the designer and Register) the monitoring at the firm is to include per each welded joint recording of the following information:

.1 identification of technologically self-contained welded joint with value of its extent;

.2 WPS identification No.;

.3 working No. (certificate) of welder;

.4 identification of personnel taking part in acceptance control operations at all stages of manufacture and with all control methods;

.5 data on discrepancies between assembly and welding quality and requirements of regulating documents, also on performed corrections;

.6 acceptance control results with indication of test record Nos.

2.7.4.5 The assembly and welding technology is to be worked out in such a way, as to minimize, as far as possible, angular strains, buckling of structures, also residual stresses.

When it is necessary to weld plates, sheets, etc, into a rigid contour some technological measures are to be taken to reduce stresses caused by welding. The rigid contour is a cutout with closed perimeter, one of the dimensions of which is less than 60 thicknesses of plates in a particular place. In complicated structures the contour can be considered rigid even at larger proportions of cutout dimensions.

2.7.4.6 Structures and parts are not to be displaced or subjected to vibration in the course of welding. Sections to be assembled afloat or suspended from cranes are to be fixed reliably in temporary assembly jigs or fastened by tack welds to exclude the possibility of their displacements during welding.

2.7.4.7 Straightening of structures is only permissible within a limited scope. Shipbuilding steels of normal and higher strength can be subjected to thermal straightening with mechanical action or without it. No damage to weld or plate surface is allowed. The temperature of heating in thermal straightening is not to exceed 650 °C, but in any case the heating is not to cause structural transformations in the metal.

2.7.4.8 Weld root adjustment in welded joints with full penetration, may be done by thermal gas gouging, electric arc (gas-arc) gouging, also by mechanical method, meeting the requirements listed below.

After thermal gas gouging the surface of the groove and adjoining surfaces at a width of 100 mm to both sides from the part edge in the joint are to be cleaned of slag, millscale, metal rolls and sparks. The surface of the groove is to be clean and smooth, free from sharp changes in depth and width over the whole length of the joint.

After electric arc gouging the surface of the groove and electrode closing spots are to be dressed to bare metal. Dressing of surfaces of grooves formed in the course of gouging and surfaces adjacent to them, as well as places of electrode contacting with metal, is to be performed with the use of abrasive tools. Acceptance of gouged surfaces may be made using reference specimens with appropriate external appearance.

The shape of edge preparation after removal of the weld root is to be such as specified in the acting regulating documents, or as shown in the drawings, and/or required by the welding process specification.

The thermal gouging is to be performed at the same air temperatures as are admissible for welding of the parts in question, observing the respective requirements for use of preheating.

2.7.4.9 The automatic submerged-arc welding (wire plus flux) is employed for joints in downhand positions. The permitted angle of joint slope towards the horizon is up to 8° along the weld and up to 15° across the weld.

For welding methods allowing to carry out welding in various spatial positions the electrode diameter are to satisfy the recommendations and/or limitations of the welding consumables manufacturer for specific conditions of their application.

2.7.4.10 Before starting automatic or semi-automatic arc welding of structures or products, the welding conditions stipulated by the technological process in accordance with the WPS, are to be checked on test bars. The thickness of test bars is to correspond to the minimum thickness of the joint parts to be welded.

2.7.4.11 When welding a joint, the weld beginning portion of 20 to 30 mm in length and the weld end of 30 to 40 mm in length are to be executed on technological bars fitted prior to welding. If on the ends of the joint an allowance has been signed of at least 30 mm in size, the technological bars are not needed, the beginning and ending portions of the weld will be located on the allowance metal.

It is allowed to do without technological bars in joints completed by manual arc welding and semi-automatic gas shielded welding.

The dimensions of technological (extension) bars are to correspond to the thickness t of parts to be welded and to welding method:

.1 the thickness of bars is to be equal to the thickness of parts to be welded. For joints with thickness above 20 mm made by two-side welding bars of lower thickness may be employed;

.2 for joints made by one-side automatic submerged-arc welding on copper sliders the starting technological bar is to have dimensions $200 \times 100 \times t$ mm, the end bar — $600 \times 400 \times t$ mm;

.3 for joints made by electrogas vertical welding with forced formation of the weld the dimensions of technological bars are to be $700 \times 450 \times t$ mm;

.4 for joints made by methods other than those mentioned above the dimensions of extension (starting and ending) bars are $100 \times 100 \times t$ mm.

The extension bars fitted in joints with edge preparation are to have the same type of edge preparation. The use of extension bars without edge preparation is also permitted, if the joint is to be welded from two sides.

2.7.4.12 When the welding is done without extension bars, it is not permitted to strike the arc or to have an arc crater on the surface of base metal outside the weld zone. At completion of the welding the arc is to be extinguished only after filling of the crater with metal.

2.7.4.13 In using of two-side welds the welding is to be started from the side opposite to the side with tack welds. To start welding from the side with tack welds is allowed when in assembling of the joint it was difficult to tack-weld on the other side and if there is a special instruction to this effect in the WPS.

2.7.4.14 In multilayer welding the beginning and the end of each subsequent layer are to be displaced by 20 to 30 mm in relation to the preceding layer towards the side opposite to the direction of welding. When making curvilinear joint the welding is not to be started or ended in places of turn.

2.7.4.15 After completion of each layer and of the weld as a whole, it is necessary to dress the weld metal and heat affected zone for removal of slag and metal sparks. The dressing is to be done after cooling down of the slag crust.

If the arc gets extinguished in the process of welding, the weld crater and adjoining portion from 10 to 15 mm in length are to be cleaned from slag. The arc-striking is to be performed at a dressed portion of the weld.

2.7.4.16 To receive the necessary dimensions of weld in manufacturing a structure with intersecting welded joints it is necessary, before starting automatic arc welding at the intersecting portion, to remove the weld of the first joint with subsequent restoration of the edge preparation structural elements, if the joint has bevelled edges, or to remove root reinforcement, if the edges are without bevel.

2.7.4.17 The manual and semi-automatic welding are to be carried out symmetrically, moving from the middle of the structure to its sides at joint lengths >2 mm and running on at lengths $\leqslant 2$ mm.

Tee joints without edge preparation may, as a rule, be welded in one runs, if the fillet weld leg does not exceed 8 mm.

2.7.4.18 Welding of parts manufactured from a shipbuilding steel by cold bending may be done without heat treatment, if the internal radius of the bend corresponds to the standards. In the absence of such standards the radius is to be not less than three plate thicknesses.

2.7.4.19 In the course of welding operations it is necessary to observe and confirm, by permanent monitoring, the conditions of storage, calculation, preproduction inspection (if required) and repeated issue of unconsumed welding materials specified in the requirements of respective technical documents and recommendations of the welding consumables manufacturer. Special attention is to be paid to materials susceptible to absorption of moisture from the ambient air, to coated electrodes, welding fluxes, flux-cored wires employed for welding of higher and high strength steels.

2.7.4.20 The shielding gases and their mixtures used for welding are to have controllable cleanness and dew point complying with the requirements of national standards and/or requirements of the documents for welding technology. Unless otherwise agreed with the Register, the provisions of Table 2.7.4.20 are to be fulfilled.

Table 2.7.4.20

Requirements with respect to dew point and humidity of shielding gases and their mixtures used for welding

Group	Dew point at 1,013 bar, °C, not more than	Humidity, PPm, not more than
R	–50	40
I	–50	40
MI	–50	40
M2	–44	80
M3	–40	120
C	–35	200
F	–50	40
Oxygen	–35	200
Hydrogen	–50	40

2.7.4.21 The equipment used for welding operations is to be capable to ensure duties and parameters specified by the technological process. For setting and control of the welding duty parameters for correct readings, the welding equipment must be provided with serviceable measuring instruments:

automatic welders — with an ampermeter, voltmeters, speed indicator or special scale for speed setting;

semi-automatic welders — with an ampermeter and voltmeter;

mechanized gas-shielded welding stations — with gas consumption control devices;

manual welding stations — with an ampermeter.

In manual arc welding the required value of current may be set by current meters at ballast resistors, with periodic checking by a portable ampermeter.

2.7.5 Welding of structures in contact with water on one side. Underwater welding.

2.7.5.1 Welding of structures having their back side in contact with water is subject to special consideration by the Register in each particular case and is to be carried out taking into account the provisions and requirements given below.

The main factor of risk in welding under conditions mentioned above is a higher probability of cold cracking in the weld and adjoining metal resulting from:

high speed of cooling of the weld and adjoining metal causing formation of structures with higher hardness;

possibility of the presence of condensate and other types of moisture on edges to be welded.

In view of the above, in welding operations on structures with water on back side, the following measures are to be taken:

.1 it is necessary to use welding consumables with controllable content of diffusive hydrogen satisfying the requirements for indices HH and HHH, see Table 4.2.1.4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships;

.2 when welding steels of normal strength it is necessary to take measures to remove condensate and other traces of moisture from the edges to be welded by thermal drying of the edges prior to welding;

.3 when welding steels of higher strength it is necessary in all cases to carry out drying and preheating of edges to be welded using a gas burner. The given operation is to be performed with the lowest possible interval of time between the drying and welding;

.4 when welding steels of higher strength with carbon equivalent $C_{equiv} \geqslant 0{,}45$ per cent it is necessary to conduct additional tests for approval of welding technological process on samples which simulate actual conditions of joints welding. The program of testing is to be specially considered by the Register in each particular case;

.5 welding of high-strength steels on structures having contact with water on the back side of their welds is not permitted.

2.7.5.2 Work in cutting and welding of structures under water in each case is subject to special consideration by the Register. In such operations the following provisions are to be used:

.1 thermal cutting and welding of structures under water by "wet method" (without isolation of the welding zone from the surrounding environment) may be used in extreme cases. About execution of such operations the Register is to be informed immediately, and the welded joints made by this method are to be removed and replaced as soon as possible using the technology approved by the Register;

.2 if it is necessary to perform some work in welding of structures under water, the "dry method" of welding is to be used, which specifies complete isolation of the welding area with the use of various facilities (caissons, unmanned or manned chambers, etc.);

.3 the welding procedures used in such jobs are subject to the Register approval obtained after testing in accordance with a separate program. This program is to be orientated to conduction of the tests under conditions simulating in the largest degree the actual conditions: they are to take into account the composition and pressure of the medium in the isolating device, length of power feeder cables, particular features of heat removal and cooling, techniques for drying and preheating of edges to be welded, etc.

2.8 PARTICULAR FEATURES OF HIGH-STRENGTH STEEL STRUCTURE WELDING

2.8.1 The provisions of the present Chapter apply to manufacture of high-strength steel structures meeting the requirements of 3.13, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, and are also applicable to steels supplied in accordance with international and national standards and having a similar level of properties and similar requirements to chemical composition.

2.8.2 The welding consumables used in manufacture of high-strength steel structures are to satisfy the requirements of Section 4 of the present Part; 4.6, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships, and the employed technological processes are to be approved by the Register in accordance with the provisions of Section 6, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

2.8.3 In welding of high-strength steel structures the provisions of 2.7 are to be observed taking into account special requirements listed below.

2.8.4 It is recommended to use welded joints of symmetrical form, both in dimensions of reinforcement and shape of edge preparation. The symmetrical form of welded joint is achieved by symmetrical edge preparation or by preliminary asymmetrical edge preparation with subsequent shaping of the joint to give it a symmetrical form.

The welded joints of asymmetrical form are used when it appears necessary due to special design features of the product.

2.8.5 In butt joints between parts of different thickness it is necessary to provide for one-side or two-side bevel at the edge of the larger thickness part with a slope not exceeding 1:5.

N o t e . It is permitted to do without bevel, if one edge is higher than the other by not more than:
1,5 mm for parts with thickness below 20 mm;
2,5 mm for parts with thickness >20 up to 30 mm;
3,5 mm for parts with thickness >30 up to 40 mm;
4,0 mm for parts with thickness >40 up to 50 mm;
for larger thicknesses: not more than 0,08*t*.

It is recommended to remove the bevel mechnanically. The weld dimensions in cases of bevel removal are measured at the part of smaller thickness. If there is no equipment available for bevel removal by mechanical methods, it is permissible to remove the bevel by thermal cutting with subsequent dressing by an abrasive tool.

When the border of reinforcement is located at a distance from the beginning of the flat equal to 10 mm or less, it is necessary to stipulate the minimum overlap of the flat by 2 mm with smooth transition to the base metal.

2.8.6 To improve the reliability and serviceability of welded structures, the welds are to be located at the largest possible distance from each other.

The recommended minimum distance between the weld borders for parts with thickness up to 40 mm is indicated in Table 2.8.6.

T a b l e 2.8.6

100 mm	60 mm
Between rectilinear welds	Between curvilinear welds with radius below 250 mm
Between curvilinear welds with radius of 250 mm and above	Between curvilinear welds with radius below 250 mm and rectilinear welds
Between curvilinear welds with radius of 250 mm and above and rectilinear welds	Between curvilinear welds with radius below 250 mm and curvilinear welds with radius of 250 mm and above

For parts with thickness above 40 mm the minimum distance between the weld boundaries in all cases is to exceed 2,5 thickness of the parts.

2.8.7 For special and primary structural elements with their high cyclic loading, the required service life can be obtained by application of special design and technological measures:

.1 grinding of butt-welded joint on both sides flush with the base metal or machining to match the radius of the T-joint;

.2 plastic surface treatment of transition zone between the weld and base metal.

.3 argon-arc melting (TIG) of transition zone between the weld and the base metal.

The details of weldment implementation with application of the measures mentioned above are to be given in the drawings and are subject to approval by the Register at the stage of consideration of technical documents for manufacture of welded structures.

Implementation of the above measures is to be based on the results of the fatigue strength evaluation in accordance with the method approved by the Register.

2.8.8 In execution of fillet welds the preference is to be given to welding with a free edge extended by a value of at least two thicknesses of the part to be welded on, see Fig. 2.8.8-1. If it proves to be impossible to execute fillet joints, as shown in Fig. 2.8.8-1, one can compensate for it by overlapping the edge end faces with weld reinforcement. In such a case the distance between the weld-to-base metal transition zone and the free edge boundary is not to exceed $1/3t$ or 8 mm (whichever is the less), as illustrated in Fig. 2.8.8-2 (see also 2.6.2.3).

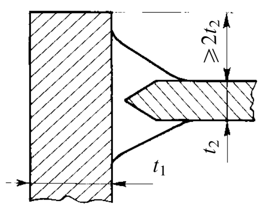


Fig. 2.8.8-1

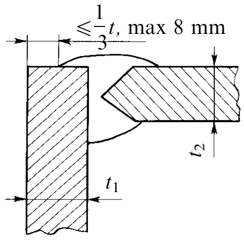


Fig. 2.8.8-2

2.8.9 When forming cruciform welded joints (splitted T-joint) the most preferable solution is extension of the main (non-splitted) part by a value of at least three thicknesses of the abutting workpiece (Fig. 2.8.9-1). If it is not possible to produce a cruciform (non-splitted tee) joint, as specified by Fig. 2.8.9-1, the edge of the main non-splitted part is to be arranged within the same plane with parts welded to it from both sides. In this case the reinforcement of weld is to overlap each of the gaps by at least 2 mm, as shown in Fig. 2.8.9-2 (see also 2.6.2.3).

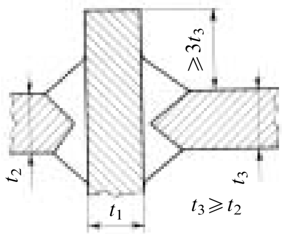


Fig. 2.8.9-1

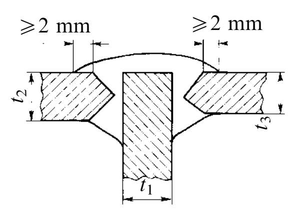


Fig. 2.8.9-2

2.8.10 Edge preparation for welding and removal of the bevel (when joining parts of different thickness) is better be performed by mechanical method. If the preparation of edges was done by thermal cutting or if there are protective shop primer coatings remaining on the edges and adjoining surfaces of parts assembled for welding, the above surfaces are to be dressed with the use of abrasive tools, as indicated in Fig. 2.8.10.

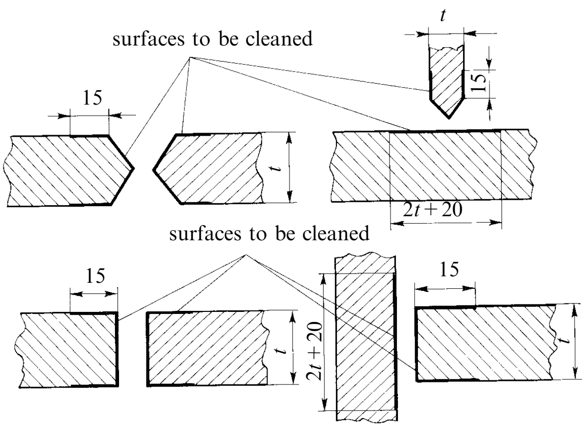


Fig. 2.8.10
Diagram of cleaning of edges in parts to be joined

N o t e. Welding of high-strength steel parts without preliminary removal of shop primer from the edges to be welded is a subject of special consideration by the Register. The required permission may only be given on the basis of tests (see also 2.7.1.5), including determination of diffusive hydrogen content in the metal deposit of welding materials, namely coated electrodes.

2.8.11 The butt faces of edges in basic and special structures not intended for welding are to be cleaned after thermal cutting with an emery disk, or machined, to give them the roughness of $R_z \leqslant 80$ mkm.

In such cases any sharp corners on free edges are not permitted, they are to be rounded in accordance with the requirements of design documents for manufacture of structures.

2.8.12 Eyes, lugs and temporary fastening attachments are to be welded on with the use of "annealing beads" applied by manual welding with coated electrodes, or by manual argon-arc with tungsten electrode, or by mechanized gas-shielded welding. Welding consumables employed for the purpose, as well as welding work conditions are to satisfy the requirements for welding of steels of respective grades (see also 2.7.1.13).

2.8.13 The temporary fastening welds are to be removed by gas cutting or by arc-air gouging leaving "stubs" of 0,5 to 3,0 mm height over the surface of the base metal with subsequent dressing of them with abrasive tools (to make them flush with metal surface) and checking for absence of cracks. The control is effected by visual examination with the aid of a magnifying glass with at least X2 magnification. In questionable cases, also if demanded by the Register surveyor, the control is to include the use of capillary or magnetic particle methods.

2.8.14 Elimination of individual defects on the base metal surface, which result from removal of temporary fasteners is to be carried out observing the requirements of 3.2.7, Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

It is permitted to eliminate by local dressing defects with depth up to 1,0 mm at metal thickness of up to 20 mm inclusive and up to 1,5 mm at metal thickness above 20 mm.

For repair of defects with depth above 3 mm by welding with subsequent dressing a request is to be submitted to the Register for approval of repair technology, including the WPS.

Repair of defects with depth up to 3 mm inclusive by welding with subsequent dressing can be carried out by agreement with the Register surveyor.

The defects may be rewelded only after dressing by an abrasive tool with subsequent checking of the dressed spots for absence of cracks. The rewelding is to be done with the use of welding consumables admitted by the Register for steels of appropriate grades, observing all the requirements for welding work. The rewelded spots, after dressing down to the rated thickness, are to be checked for absence of cracks using dye penetrant testing.

2.8.15 The most preferable for welding of high-strength steel structures is multirun welding with weld root dressing for joints with full penetration. Use of one- or two-run technique, electroslag or gas-arc welding, as well as multiarc and one-side welding is a subject for special consideration by the Registe (see also 2.5.5).

2.8.16 In work involving welding of high-strength steel structures the respective provisions of 2.7.2 and 2.7.3 are to be observed in full, taking into account the provisions and additional requirements listed below:

.1 the minimum preheat temperature and temperature between runs are to be in compliance with the requirements of Table 2.8.16;

.2 when welding is carried out at open-air sites, the welding zone and adjoining surfaces at a width of at least 100 mm to both sides from the joint edges are to be dried with gas burner flame until all moisture is fully removed. If in the course of multirun welding some breaks occur in the work, the drying of the welding zone is to be repeated before application of the next bead;

Table 2.8.16

Requirements for preheating temperature in welding of high-strength steels

Grade of steel to be welded	Metal thickness, mm	Ambient air temperature, °C	Content of diffusible hydrogen in deposited metal, $cm^3/100$ g	Minimum temperature of preheat, °C	Minimum between runs, temperature °C
(A/F) 690	up to 130	0 and above	up to 3,0 (H3)	80	80
			above 3,0 to 5,0 (H5)	100	80
		below 0 to −10	up to 3,0 (H3)	120	100
			above 3,0 to 5,0 (H5)	130	120
		below −11 to −15	up to 3,0 (H3)	Subject to special consideration	
(A/F) 620 and (A/F) 550	up to 40	0 and above	up to 3,0 (H3)	40	50
			above 3,0 to 5,0 (H5)	60	60
		below 0 to −15	up to 3,0 (H3)	80	80
			above 3,0 to 5,0 (H5)	100	80
		below −16 to −20	up to 3,0 (H3)	Subject to special consideration	
	41 — 100	0 and above	up to 3,0 (H3)	60	60
			above 3,0 to 5,0 (H5)	100	80
		below 0 to −15	up to 3,0 (H3)	120	80
		below 0 to −15	above 3,0 to 5,0 (H5)	120	100
		below −16 to −20	up to 3,0 (H3)	Subject to special consideration	

Table 2.8.16 — continued

Grade of steel to be welded	Metal thickness, mm	Ambient air temperature, °C	Content of diffusible hydrogen in deposited metal, $cm^3/100$ g	Minimum temperature of preheat, °C	Minimum between runs, temperature °C
(A/F) 500	up to 40 inclusive	0 and above	up to 3,0 (H3)	no preheat	50
			above 3,0 to 5,0 (H5)	40	50
			above 5,0 to 10,0 (H10)	60	60
		below 0 to −15	up to 3,0 (H3)	60	80
			above 3,0 to 5,0 (H5)	80	80
		below −15 to −20	up to 3,0 (H3)	100	80
	above 40 to 100 inclusive	0 and above	up to 3,0 (H3)	60	60
			above 3,0 to 5,0 (H5)	80	80
		below 0 to −15	up to 3,0 (H3)	80	80
			above 3,0 to 5,0 (H5)	100	80
		below −15 to −20	up to 3,0 (H3)	Subject to special consideration	
(A/F) 460 and (A/F) 420	up to 40 inclusive	0 and above	up to 3,0 (H3)	no preheat	40
			above 3,0 to 5,0 (H5)	40	50
			above 5,0 to 10,0 (H10)	60	60
		below 0 to −15	up to 3,0 (H3) above 3,0 to 5,0 (H5)	50	50
			above 5,0 to 10,0 (H10)	80	60
		below −15 to −20	up to 3,0 (H3) above 3,0 to 5,0 (H5)	100	80
	above 40 to 100 inclusive	0 and above	up to 3,0 (H3) above 3,0 to 5,0 (H5)	40	50
			above 5,0 to 10,0 (H10)	60	60
		below 0 to −15	up to 3,0 (H3) above 3,0 to 5,0 (H5)	60	60
			above 5.0 to 10.0 (H10)	80	60
		below −15 to −20	up to 3,0 (H3)	100	80

N o t e s :

1. The table specifies the minimum level of requirements concerning the preheating temperature and temperature between runs for hardened and tempered steels on the basis of tendency to cold cracking. When such requirements are satisfied, the Register accepts the Welding procedure specification for consideration.
2. For steels of grades (A/F)500, (A/F)460 and (A/F)420 manufactured with the use of thermomechanical treatment and accelerated cooling and having $C_{equiv.} \leqslant 0,41$ %, lower preheat and temperatures between runs are acceptable.
3. Actual values of preheat temperature and temperature between runs are to be approved by the Register on the basis of tests for approval of welding technological processes, including control of all limiting parameters of a particular project (maximum hardnesss of the heat affected zone, values of CTOD for the heat affected zone and the weld, etc.).

.3 the preheating is to be carried out with the use of resistance heaters, gas or electric infra-red heaters, induction heaters. In certain cases it is permitted to use heating with open flame of gas burners;

4 the temperature between runs may be maintained at the required level by heat input coming directly from the process of welding, i.e. autopreheat, or by heat from external sources;

.5 the preheat temperature before welding and temperatures in the process of welding are subject to mandatory monitoring of the results by the manufactural control services in accordance with established procedure;

.6 in cases of welding with coated electrodes in conditions of absolute air humidity equal to 12 g/m^3 or more the welding zone preheat to at least 50 °C is required, unless it is was specified earlier, or increase in minimum preheat temperatures and temperatures between runs by 20 °C (see Table 2.8.16);

.7 in cases of unforeseen interruptions in multirun welding with preheat decelerated cooling of the welded joint is to be ensured, and before resumption of the welding the joint edges are to be preheated to the required temperature;

.8 when welding steels of various grades and thicknesses the required preheat temperature and temperatures between runs are to be specified taking for reference the steel for which such temperatures are the highest.

2.8.17 Efficient autopreheating of edges to be joined by manual (with coated electrodes and argon-arc with tungsten electrodes) welding and semiautomatic gas-shielded welding may be achieved by using the block method. The method consists in subdividing of a technologically self-dependent joint into several portions (blocks) equal in length welded simultaneously by several welders, the block length depends on the thickness of parts to be welded; the following values are recommended:

up to 2000 mm in welding of steels up to 40 mm inclusive in thickness;

up to 1500 mm in welding of steels from 40 to 70 mm inclusive in thickness;

up to 1200 mm in welding of steels above 70 mm in thickness.

Welding of all the blocks is to be carried out simultaneously over the whole length of technological portion without breaks until the joint gap or full cross-section of the weld is filled. All beads within a block are to be applied throughout the length. In two-side joints the welding, if possible, is to be done from both sides simultaneously.

The beginning and end of each layer in a block are to be displaced by 20 to 30 mm in relation to the preceeding layer. It is not permissible to butt the blocks at the intersections of welds.

2.8.18 When root beads are made by manual arc welding (with coated electrodes and by argon-arc welding with tungsten electrodes), as well as by semiautomatic gas-shielded welding, additional measures are to be taken to avoid cracking.

One of the recommended measures is application of the "bead bond" method (Fig. 2.8.18), as well as increase in the bead height up to 6 to 8 mm in the cross-section height on each side of the joint.

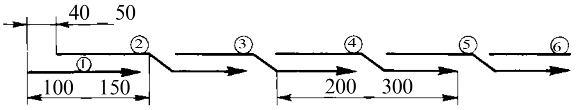


Fig. 2.8.18
Diagram of welding of root runs in application of "bead bond" method

2.8.19 In welding of special structures, as well as primary structures in contact with sea water the last run of the weld is to be applied using the method of "annealing bead", see Fig. 2.8.19. The annealing bead is applied in such a way as to overlap about two thirds of the width of the bead (run) extreme in relation to the base metal surface.

When using temporary assembly attachments (see 2.8.12) fastened by fillet welds without edge preparation, the annealing bead can be applied as additional, with respective asymmetrical increase in dimensions of fillet weld (see Fig. 2.8.19).

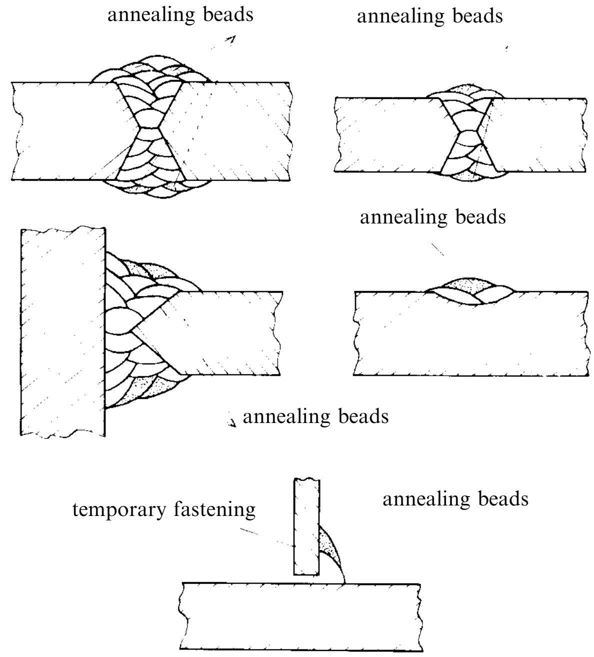


Fig. 2.8.19
Diagram showing the sequence of layers in application of "annealing beads"

2.8.20 When carrying out welding jobs at open-air sites it is allowed, by a special permission of the Register, to take special measures enabling to weld structures without preheatingg or with considerable reduction in preheat temperature. Such measures include:

.1 application of special types of high-alloyed welding consumables of austenitic or austenite-ferrite class;

.2 preliminary surfacing (with subsequent treatment) of edges to be welded in shop conditions, including the use of welding consumables of lower strength grade (but not affecting the impact bending test temperature).

2.8.21 At thermal treatment (tempering for relieving of residual stresses) of welded structures made of high-strength steels it is necessary to take into account a possibility of emergence of additional unfavourable factors:

.1 formation of tempering cracks (of the first and second type) in the welded joint;

.2 tendency to embrittlement at tempering of the heat affected zone in certain grades of steel micro-alloyed with niobium and vanadium, especially when they are welded with high heat input (above 35 to 40 kJ/cm).

N o t e. The tendency of steels to cracking can be detected by simultaneous appearance of positive values of parameters ΔG and P_{SR} calculated by the formulae:

$\Delta G = Cr + 3{,}3Mo + 8{,}1V + 10C - 2$;

$P_{SR} = Cr + Cu + 2Mo + 10V + 7Nb - 5Ti - 2$,

where Cr, Cu, Mo, V, Nb, Ti, C means percentage content of the respective elements in steels.

This is why the nondestructive testing of welded structures is to be carried out after their heat treatment, including here use of test methods ensuring high detectability of in-plane defects.

2.8.22 The possibility of application and technology of thermal straightening of structures made of high-strength steels are to be specified on the basis of the steel manufacturer recommendations.

Permission for thermal straightening is granted by the Register depending on the results of tests conducted in accordance with a special program. The test procedure is to take into account integrated action of all unfavourable factors taking place in manufacture of structures in production environment. The test results are considered positive, if the properties of the base metal and weld after thermal straightening are in compliance with the level of respective requirements of the Rules for the base metal and weld in the initial state.

Under such conditions simulation of the actual thermal and deforming action on metal in thermal straightening of actual structures can be effected with the use of large-size simulation samples.

2.9 WELDING OF CLAD STEELS

2.9.1 The requirements of the present Chapter apply to welding of clad steels manufactured by various methods and of these steels joining to stainless and low-alloyed steels.

2.9.2 The welding consumables employed in manufacture of parts and structures made of clad steels are to be approved by the Register and, depending on their function, meet the requirements listed below:

.1 the basic layer is to be welded, as a rule, with the use of low-alloyed consumables approved for welding of steels compatible in composition, or grade, and properties with the basic layer;

.2 the cladding layer is to be welded with the use of consumables approved for welding of stainless steel corresponding in composition and properties to cladding layer metal. In this case one of the main requirements is to ensure corrosion resistance of the weld metal at the level of requirements to the cladding layer taking into account the future service conditions (temperature and corrosive action of the environment);

.3 the interlayer (transitional from low-alloyed weld metal to high-alloyed cladding metal) is to be welded with the use of high-alloyed consumables approved for this purpose or for welding of heterogenious materials. In this case the main requirement is absence in the interlayer of crack-type defects due to generation of brittle components at considerable dilution (up to 40 per cent) of the deposited metal coming from the lower runs (of the basic layer);

.4 if the technological process requires welding of the basic layer with high-alloyed materials, the latter are to have approval for:

welding of heterogeneous joints (of low-alloyed to high-alloyed), if there is no buttering of edges with welding consumables intended for the interlayer;

welding for stainless steels of the appropriate type (compatible with the cladding layer), with preliminary buttering of edges at the basic layer. It is to be understood that the whole weld is produced employing the consumables corresponding to the cladding layer.

N o t e. For the interlayer and heterogeneous joints high-alloyed filler materials of type X2CrNi2412(AISI:309L), X10CrNi2412 (AISI:309S), X10CrNiCb2412 (AISI:309SCb) are generally to be used.

2.9.3 The welders working with clad steels must first are to have the required training and to be admitted by the Register on the basis of practical tests conducted in accordance with a special program.

N o t e. The welders having admittance certificates with the scope of approval covering several individual groups of low-alloyed and stainless steels may be admitted by the Register for welding of clad steels in the way of exception (provided their practical experience in welding of clad steels may be confirmed).

2.9.4 Approval of technological processes for welding of clad steels is carried out by the Register using individual programs, and the scope of testing is specified individually in each particular case, taking into account:

.1 type of joint and particulars of edge preparation (indicating here also, whether some cladding material is to be taken away or not);

.2 employed welding technological processes and sequence of welding of basic and cladding layers;

.3 availability at the manufacturer of welded structures of the Register approval of technological processes in which similar welding consumables and base metals are indicated separately for the basic and cladding layer;

.4 requirements to corrosion resistance of the cladding layer weld metal subdivided by types of corrosion damage (intercrystalline corrosion, pit corrosion, hydrogen sulphid cracking).

2.9.5 When selecting the design elements of edge preparation for welding the following particular features of clad steel welding technology are to be taken into account:

.1 as a rule, first the weld on the basic layer side is to be made and only after that the weld on the cladding layer side;

.2 when the weld on the basic layer side is made with the use of low-alloyed consumables, the possibility of partial melting of the cladding layer is to be excluded;

.3 before welding of the cladding layer the weld root is to be dressed by machining;

.4 before welding of the cladding layer, as a rule, an intermediate transition layer is to be introduced with the use of high-alloyed filler consumables of a special type;

.5 the weld on the cladding layer side is to consist of at least two layers. In some cases involving processes with insignificant base metal presence in the weld metal (as in the case of plasma overlaying) and at the appropriate level of filler consumable alloying it is permissible, by agreement with the Register, to make the cladding weld in one layer having the thickness not lower than that of the base metal cladding layer;

.6 when welding the joint on the cladding and basic layer side, a possibility is to be provided, if possible, for deposition of annealing beads. For this purpose in butt joints a partial removal of cladding metal adjoining to the edges to be welded may be effected (on a width of 4 to 8 mm to both sides), or the groove angle may be increased;

.7 when welding butt joints with two-side edge bevel and producing the basic layer on the cladding side with the use of low-alloyed consumables, measures are to be taken to exclude the possibility of partial melting or damage to the base metal cladding layer. For this purpose it is permissible to remove the base metal cladding layer on a width of 4 to 8 mm to both sides of the groove;

.8 in tee and cruciform joints with complete penetration and with high level tensile stresses (especially at dynamic loads) it is recommended to employ welding with partial removal of the cladding layer on the main (non-split) part.

The examples of welded joints made in accordance with the above requirements and recommendations are given in Figs. 2.9.5-1, 2.9.5-2 and 2.9.5-3.

2.9.6 In manufacture of structures and components from clad steels care is to be taken to protect

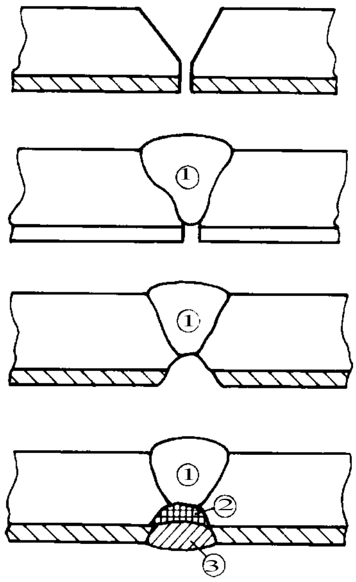


Fig. 2.9.5-1

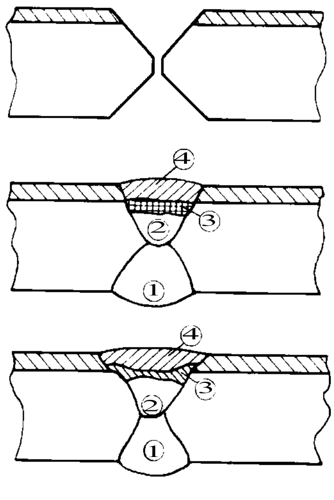


Fig. 2.9.5-2

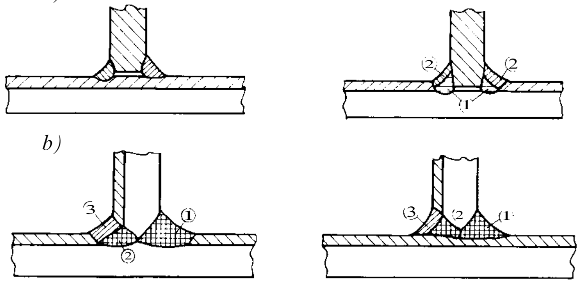


Fig. 2.9.5-3

the cladding layer surface against damage and contamination with foreign metal inclusions.

Tack welds and temporary setting-up fixtures employed in assembly of clad steel structures for welding are to be located on the side of basic layer. It is not allowed to fit the temporary setting-up and levelling (by welding) fixtures on the side of cladding layer.

2.9.7 Preparation of edges for welding is to be performed by mechanical methods.

In case of application of thermal cutting (such as plasma or laser cutting) it is necessary to subject the edges to additional dressing. The depth of mechanical dressing on the cladding layer side is to be 1,0 to 1,5 mm. When welding together parts with different thickness the excessive bevel is to be removed by a mechanical methods on the basic layer side.

2.9.8 The technological processes and conditions of clad steel welding are to meet the requirements of respective regulating documents and instructions of consumables manufacturers. Besides, the following requirements and recommendations are to be taken into account:

.1 cutting-out of the weld root on the cladding layer side can only be done by milling or grinding;

.2 for welding of the cladding layer, as far as possible, the electrodes and welding wire of small diameter are to be used and the welding is to be carried out with low energy input;

.3 when the cladding weld is executed in two layers, it is permitted to carry out preliminary levelling of the preceding layer metal surface by mechanical methods or grinding (this applies to the intermediate layer and the first cladding layer).

2.9.9 The technology of welding of clad pipes with one-side access (from the basic layer side) allows the use of the following patterns ensuring the acceptable level of the welded joint quality:

.1 a cladding layer is produced by one-side unsupported welding with back formation of the weld root (as a rule, the best results are obtained using inert gas shielded welding with non-consumable electrode and additional gas back-up). It is recommended to select filler consumable with a higher degree of alloying in comparison with the cladding layer (and, respectively, with a higher corrosion resistance), because partial melting of the basic layer metal is inevitable anyway. Filling of the groove within the basic layer is performed using high-alloyed filler consumable suitable for welding of heterogeneous joints (such as AISI: 309, 309L, 309SCb);

.2 a cladding layer is produced by one-side unsupported welding, as specified in 2.9.9.1 above. Filling of the groove within the basic layer is performed using consumables intended for stainless steels, over preliminarily battered edges. For battering of the edges consumables intended for deposition of the intermediate layer are used;

.3 a cladding layer is produced by one-side unsupported welding, as specified in 2.9.9.1. Over the root run a two-layer deposition is made with the use of filler consumables based on commercially-pure iron, ensuring the minimum intermixing of metals in the layers. Filling of the groove within the basic layer is done with the use of low-alloyed consumables fully corresponding to the grade or brand of steel in the basic layer of the clad steel;

.4 the whole joint cross-section, including the root portion and groove, is welded with the use of high-alloyed filler consumables on nickel base (such as alloys of type Inconel. 625: 62Ni-22Cr-9Mo and others). In this case there is no need for edge buttering in the basic layer.

The particular version of clad pipe welding is to be selected taking into account the strength features of the basic layer and the wall thickness. For instance, for thick-wall clad pipes made of high-strength steel the most suitable version may be the one described in 2.9.9.3.

2.9.10 The welding technology for butt joints between clad steel and stainless steel permits the use of the following groove filling arrangements (Fig. 2.9.10):

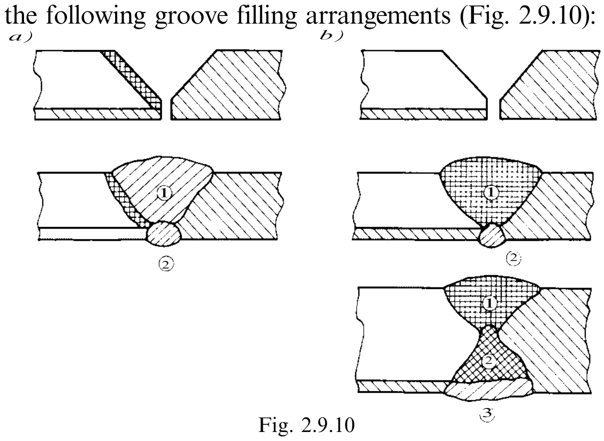


Fig. 2.9.10
1, 2, 3 — sequence of weld building-up

.1 the welding is done over the whole joint cross-section with the use of filler consumables intended for cladding layer welding. In this case it is required to carry out preliminary buttering of edges to be welded on the side of the clad steel basic layer with the use of filler consumables intended for deposition of intermediate layers (Fig. 2.9.10 (*a*));

.2 from the side of the basic layer the welding is done with high-alloyed consumables intended for heterogeneous joints after mechanical dressing of the weld root; from the cladding side a two-layer cladding deposit is applied with the use of stainless filler consumables (suitable for joints with single bevel) (Fig. 2.9.10 (*b*)).

N o t e . In joints with double bevel the groove is first filled flush with the cladding lower edge with materials intended for welding of heterogeneous joints, after that a two-layer cladding deposit is applied using stainless filler cobsumables. Examples of fillet welds in T-joints in structures made of stainless and clad steels are shown in Fig. 2.9.5-3.

2.9.11 In welding of butt joints between clad and low-alloyed steels the following sequence of operations is to be observed (Fig. 2.9.11):

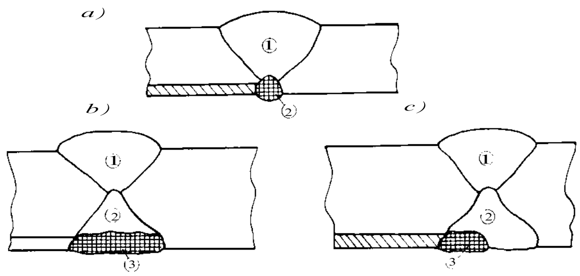


Fig. 2.9.11
1, 2, 3 — sequence of weld building-up

.1 welding from the side of basic layer with the use of low-alloyed consumables meeting the requirements of 2.5 for respective steel categories;

.2 mechanical grooving of the weld root from the side of cladding and capping of it in joints with single bevel using filler consumables intended for heterogeneous joints. In joints with double bevel first welding of the base layer of clad plate is performed, after which a single or twin layer deposition is made with the use of consumables intended for welding of heterogeneous joints.

N o t e . In two-side joints of large thickness it is permissible to make the facing beads on the cladding side not over the whole width of the groove.

2.9.12 The possibility of heat treatment and conditions of this process for clad steel parts and structures is to be established in accordance with the instructions of steels and consumables manufacturers. For certification of the welding technological processes by the Register all the necessary tests are to be conducted after heat treatment similar to that conducted in the course of manufacture.

2.10 WELDING OF STRUCTURES OF MACHINERY AND MACHINERY INSTALLATIONS

2.10.1 The present requirements cover welding of structures and products of engineering industry manufactured with the use of base materials and welding consumables meeting the requirements of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships, Part XII "Materials" of MODU/FOP Rules, as well as regulations of the present Part. Manufacture of structures of materials not covered by the Rules is to be carried out on agreement with the Register.

2.10.2 The consumables for welding of structures of machinery and machinery installations are selected for particular brands of steel employed in manufacture taking into account the requirements of 2.5.4 to 2.5.6.

If the structures are utilized at high temperatures or in a chemically-active environment, the consumables are to be selected making allowance for these factors.

2.10.3 For welding of parts of machinery and machinery installations made of steel with thickness of 30 mm and above such consumables are to be used which ensure the welded joint resistance to cold cracking, otherwise the manufacturer is to take technological measures (preheating, thermal treatment, limitation of ambient air temperature in welding, etc.) to prevent formation of cold cracks.

2.10.4 Welds in structures operating under dynamic loads are to be made with full penetration. Transition from the base metal to the weld metal is to be smooth.

2.10.5 Use of welding in manufacture of shaftlines and crankshafts is in each case subject to special consideration by the Register.

The mandatory conditions in such cases are non-destructive tests of all welds and guaranteed fatigue strength limit of welded joints fixed in the design.

The scope of required pilot welding and the test program is to be agreed with the Register before the starting of work.

2.10.6 Use of welding, building-up, metal pulverization and similar methods in manufacture and repair of engineering products may be permitted if positive results are obtained in tests conducted in accordance with the procedure agreed with the Register and confirming the possibility of application of the given method at a particular manufacturing works.

Shafts made of carbon steels (containing up to 0,45 per cent of carbon), either worn or having surface cracks, can be repaired by building-up, if the wear or depth of cracks does not exceed 5 per cent of shaft diameter, but it is not to be over 15 mm.

2.11 WELDING OF STEAM BOILERS AND PRESSURE VESSELS

2.11.1 Welds in boilers are to have marks showing which welder has done the job.

The longitudinal and circumferential welds in boiler shells are to be produced with back- sealing run, except for cases when the efficiency factor of welded joints, in accordance with 2.1.6, Part X "Boilers, Heat Exchangers and Pressure Vessels" of the Rules for the Classification and Construction of Sea-Going Ships, is $\leqslant 0,7$.

The cutouts and openings in the boiler shell are not, as far as possible, to cross the circumferential and longitudinal welds in the boiler shell.

Possibility of welding of any fastenings, catches and similar parts for erecting purposes to the boiler shell is in each case subject to special consideration by the Register.

The longitudinal and transverse welds on headers, boiler shells and pressure vessels are to be in the form of butt joints. If the abutting junction is not possible, the joint design is subject to special consideration by the Register.

2.11.2 Welding consumables for welding of boilers and pressure vessels are to be selected depending on particular grades of steel used for manufacture of the above products with due regard to 2.5.4 to 2.5.6.

2.11.3 Use of electrodes with rutile and oxide coatings for welding of boilers and pressure vessels of Class I (see 1.3.1.2, Part X "Boilers, Heat Exchangers and Pressure Vessels" of the Rules for the Classification and Construction of Sea-Going Ships) is not permitted; they may be used for boilers and pressure vessels of Classes II and III, if their structures are made of carbon steels and if the thickness of parts to be welded does not exceed 20 mm.

2.11.4 The heat treatment of boilers and pressure vessels is carried out in accordance with the standards or taking into account the recommendations of steel manufacturers.

The welded joints between parts which, due to their size or particular design, cannot be subjected to stress relief heat treatment as a whole, may be, by agreement with the Register, treated in parts. In this case the treatment is effected by uniform heating of a wide enough portion along the weld (about six thicknesses of the plate on both sides of the weld) taking care to exclude propagation of thermal stresses to adjacent portions of the parts. Local treatment by welding torch is not allowed.

2.11.5 Sealing of openings in boilers by welded-in plugs is to be performed meeting the requirements of national standards.

2.11.6 Repair of worn-out shell plates of boilers and pressure vessels by building-up is allowed only on agreement with the Register. The built-up area is not to exceed 500 cm^2, the depth is not to be more than 30 per cent of the plate thickness. If such conditions cannot be satisfied, the defective area is to be replaced with a new plate.

2.11.7 When manufacturing boilers, heat exchangers and pressure vessels of Classes I and II (see 1.3.1.2, Part X "Boilers, Heat Exchangers and Pressure Vessels" of the Rules for the Classification and Construction of Sea-Going Ships), test samples are to be prepared to check-up the mechanical properties of the welded joints in the case of unique products being manufactured, serial production on the prototype product, alterations in the structure of main parts, application of new materials and welding procedures.

The test samples for products belonging to Class III may be prepared if required by the Register.

2.11.8 The test samples are to be fixed to a longitudinal weld of the boiler or pressure vessel in such a way that the weld on the test plate is a continuation of the weld on the product. The test plates are to be welded by the same method (under the same technological conditions) as the weld on the product.

The test sample thus prepared is used to manufacture and test one transverse specimen for tension, two transverse specimens for bending, three specimens for impact bending: they are cut out as shown in Fig. 4.2.4.2, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

Specimens for structures of Class III are to be manufactured as required by the Register surveyor. The conditions of cutting-out of specimens from test samples and testing are to correspond to 4.2.3.2 and 4.2.3.3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

2.12 WELDING OF PIPELINES

2.12.1 The type of welded joints in pipelines is to be in correspondence with the standards.

2.12.2 Selection of welding consumables for welding of pipelines is made depending on particular grades of steel applied in pipe manufacture taking into account the requirements of 2.5.4 to 2.5.6.

2.12.3 The welded butt joints in pipelines are to be performed with full penetration in the weld root. Use of removable backing rings in welding is permitted.

2.12.4 Use of remaining backing rings in butt joints of pipes is permitted in those pipelines where such rings do not affect negatively the pipeline performance. The butt welded joints between flanges and pipes are not to be made on the remaining backing rings.

2.12.5 Welded joints in pipes are to be subjected to heat treatment, if the pipes are made of low-alloyed steel and in case of gas welding of main steam pipelines operating at temperatures above 350 °C.

2.12.6 When welding pipes made of chrome-molybdenum steel containing 0,8 per cent of chromium or more, and more than 0,16 per cent of carbon, the edges to be welded are to be preheated to 200 to 230 °C. This temperature is to be maintained during the process of welding.

2.12.7 The edges to be welded in copper pipes with wall thickness of 5 mm and above are to be preheated to 250 to 350 °C. Welding of copper-nickel pipes is to be done without preheating. Use of soldering for joints in copper-nickel pipelines is not allowed.

2.12.8 The possibility of pipeline repairs by rewelding of damaged areas is in each case subject to special consideration by the Register.

2.13 WELDING OF CASTINGS AND FORGINGS

2.13.1 In cases listed below welding of steel castings and forgings is to be carried out irrespective of the ambient air temperature with the use of preheating, or is to be taken other measures meeting the requirements for welded joints:

.1 when carbon content in steel of castings or forgings exceeds 0,25 per cent;

.2 when carbon content in steel of castings or forgings exceeds 0,23 per cent, if the castings and forgings are incorporated in hull structures of MODU and FOP.

2.13.2 The preheating temperature and heat treatment conditions for castings and forgings are determined depending on the design, dimensions and service conditions in accordance with 2.7.2.4, 2.7.3.1 and 2.7.3.6.

2.13.3 Defects in steel castings and forgings may be repaired by rewelding only in cases when the weldability of the given steel has been duly checked and service conditions for cast or forged parts taken into account.

Repair of defects by rewelding is to, as a rule, be performed prior to completion of the heat treatment. Rewelding after heat treatment is allowed only in exceptional cases. The defects appearing regularly in castings and forgings are not to be repaired by rewelding.

2.13.4 Rewelding of defects in castings is to be carried out after removal of sprues and heads and thorough cleaning of castings from moulding materials, millscale, foreign inclusions. The places to be rewelded are to be dressed to sound metal to ensure proper penetration throughout the welded area.

The walls in places prepared for rewelding are to be gently sloping, the surface of prepared depression is not to have any sharp corners.

2.14 WELDING OF CAST IRON

2.14.1 Repair of cast iron castings by welding is allowed on agreement with the Register surveyor using a method approved by the Register on the basis of the results of testing performed in accordance with a program agreed with the Register.

2.15 WELDING OF ALUMINIUM AND ITS ALLOYS

2.15.1 Welding operations are to be carried out by the most efficient method ensuring high-quality joint, with maximum strength, chemical composition close to that of the base metal, and sufficient corrosion resistance.

2.15.2 The welds are to be located, as far as possible, in areas of the lowest stresses.

As a rule, welding is to be carried out in the downhand position. Removal of weld reinforcement is permitted only by agreement with the Register.

2.15.3 Immediately before welding (tack welding) edges to be welded of parts made of aluminium and its alloys are to be degreased using special solvents (acetone, alcohol, etc.) and cleaned with steel wire brushes. Tacked spots before welding are also to be cleaned with wire brushes. In multirun welding each completed layer is to be cleaned with a wire brush before application of the next layer.

2.15.4 Welding consumables made of aluminium and its alloys are to be cleaned before welding to remove contaminations and oxide films.

2.15.5 Welding of aluminium alloys on permanent or removable backings is permissible. The backings removed after welding are to be made of stainless steel. The permanent backings are to be made of the same kind of alloy, of which the welded parts are made.

2.15.6 In case of two-side welding, before back run it is necessary to cut out the weld root down to clean metal by chipping, gouging or milling. Cutting out of the root by abrasive disks is not allowed.

2.15.7 Hot straightening of structures made of aluminium and its alloys is permitted. The heating temperature at straightening is to comply with the properties of the particular alloy.

2.15.8 When a flux is used for welding, it is to be neutral, if possible. If a non-neutral flux is used, as an exception, it is to be thoroughly removed after welding.

2.15.9 In areas where aluminium alloys have riveted joints all the main welding operations are to be completed before the riveting is started.

2.16 WELDING OF COPPER AND ITS ALLOYS, HEAVY METALS AND OTHER NON-FERROUS METALS

2.16.1 Welding of copper and its alloys, heavy metals and other non-ferrous metals is carried out in accordance with the national standards and in the absence of the latter it is in each case subject to special consideration by the Register.

3 INSPECTION OF WELDED JOINTS

3.1 GENERAL

3.1.1 Test methods employed.

3.1.1.1 Non-destructive testing of welds and joints may be performed using the following methods:

.1 visual examination and measurements;

.2 magnetic particle technique (magnetic particle inspection);

.3 capillary method (including dye penetrant and fluorescent penetrant inspection);

.4 radiographic inspection (including X-ray and gamma-ray testing);

.5 ultrasonic inspection;

.6 checking of proofness and tightness.

Use of a particular non-destructive testing method is specified by the requirements of 3.2 and is set forward in the project control scheme to be approved by the Register.

3.1.1.2 When drafting the control scheme the following factors influencing the revealing of defects and reliability of control are to be taken into consideration in full measure:

.1 nature and location of defects typical for the particular welding technological process;

.2 particular features of various non-destructive testing methods with respect to defect revealing taking into account their size and location;

.3 geometrical parameters of the joint limiting the possibilities of application of particular test methods;

.4 accessibility of the joint under control for fault detection, also for repairs in the course of manufacture.

3.1.1.3 The use of radiographic and/or ultrasonic inspection methods for detection and classification of internal defects is to be always preceded by detection and, if necessary, repair of all surface and subsurface defects which are revealed by methods of visual examination and measurements in conjunction with magnetic particle checking or capillary techniques.

3.1.1.4 The radiographic and ultrasonic test methods are differing essentially in properties of revealing of defects of various types and location. The radiographic method is more efficient in detection of three-dimensional discontimuities, such as porosity and flux inclusions, and it is less efficient in detection of such in-plane (two-dimensional) defects, such as cracks and faulty fusion, especially if the direction of their propagation doesn't coinside with the direction of X (gamma)-raying.

On the other hand, the ultrasonic inspection is more efficient in detection of in-plane defects which are most dangerous and inadmissible in structures irrespective of their linear dimensions.

Because of difference in physical nature and particular features of the radiographic and ultrasonic test methods there may be cases of divergence in opinion about estimation of some weld portion: according to one method it is acceptable, according to the other it is not. In such a case the decision about the checking break-down of the weld and repair of defects is to be adopted taking into account explanations of 3.1.4.8.

3.1.2 Requirements for test laboratories and personnel.

3.1.2.1 Non-destructive tests and estimation of weld quality of MODU and FOP joints are to be performed by test laboratories (centers) having the competence and status satisfying the requirements for recognition in accordance with national or international standards. The document confirming the competence of the industrial or subcontracting test laboratory is the Recognition Certificate granted by the Register or another authorized national body. In the latter case a copy of the Recognition Certificate is to be submitted to the Register surveyor prior to beginning of welding operations.

3.1.2.2 Non-destructive tests and estimation of welds and their quality are to be performed by specialists completed the required training, granted the certificates and having experience of practical work involving a particular control method: this is to be confirmed by documents. Estimation of the employees' level of skill and certification in the field of non-destructive testing is to be performed in accordance with the requirements of the national standards coordinated with EN 473. In this case the following requirements are to be complied with:

.1 the field of recognition by the Register of the non-destructive testing specialists' skill in each method is limited to only those methodical documents (standards), in accordance with which they were subjected to special and practical tests in the course of survey (as recorded in the test protocol);

.2 only specialists of at least level I skill in radiographic control may be admitted for estimation of welds (but not granted the right to issue decisions) and at least level II skill in other methods;

.3 issue of decisions on testing by a particular method, checking of equipment serviceability, as well as drafting of process control charts in accordance with the acting regulating documents are to be performed by specialists of at least level II skill;

.4 coordination of process control charts, development of control procedures for a particular method and/or product checking schemes by several methods, as well as issue of decisions based on the results of control by several methods, are to be performed by specialists of skill level III (see also 3.1.3.4).

3.1.3 Control plan and test reports.

3.1.3.1 As a rule (if it is not additionally specified in other documents approved by the Register), a plan (list) for control of welds in hull structures and pipelines (or an individual product produced under supervision of the Register) is to be submitted to the Register for consideration and approval and is to contain the following information:

.1 parts and welded joints to be controlled at the stage of acceptance of welded structures;

.2 scope and methods of control;

.3 location of portions to be controlled within the length of the weld;

.4 requirements for estimation of welded joints quality;

.5 standards for testing or written specifications for control arrangements.

3.1.3.2 After completion of welding operations on a particular structure the supervisory organ of the firm selects the places (portions) to be controlled by non-destructive method according to the control method approved by the Register. In this case the Register retains the right to change the location of individual portions to be controlled by non-destructive testing or to expand the scope of testing (to demand control of additional portions of welds) after consideration and approval of the control plan.

3.1.3.3 The documents recording the results of conducted testing are to be prepared for all kinds of tests (initial, additional and repeated after correction) and submitted to the Register surveyor together with the other documents confirming the results of testing (such as gamma-ray or x-ray photographs).

Conclusions on the results of non-destructive tests are to contain all the information required in accordance with the Register requirements for particular types of non-destructive testing.

3.1.3.4 The results of repeated tests (after correction of the faults) are to be stated separately in the test report.

Conclusions about testing are to be signed by the person directly involved in the control (non-destructive test specialist) and responsible for conduction of testing on behalf of a test center with level III skill for the test method in question.

3.1.3.5 The documentation on the weld quality inspection results are to be kept at the firm for at least 5 years and submitted, whenever necessary, to the Register, as required by the latter.

3.1.4 General requirements to acceptance control of welded joints.

3.1.4.1 The non-destructive acceptance control of welded joints is to be conducted (unless otherwise specified) after completion of all welding and straightening operations prior to painting and priming work or to electroplating, or application of other coatings.

When welding structures of higher strength steels, where cold cracks are generated by action of the delayed fracture mechanism (including action of the diffusible hydrogen), the time after completion of welding operations and prior to starting of acceptance control is not to be less than 48 h. In case of welding of high-strength steels this time interval is to be increased to at least 72 h, and in some special Register instructions for structures of high thicknesses, up to 7 days.

Note. The requirement above does not cover functional inspection conducted in the course of product manufacture in accordance with the technological process description or other documents requirements. For instance layer-by-layer control of welded joints by external examination and measurements, control of welded joints with partially filled groove, etc.

3.1.4.2 All the welded joints are to be subjected to acceptance procedure based on the results of external examination and measurements within the 100 per cent extent on both sides of the joint (if this control is technically feasible). In these circumstances all the unacceptable defects and imperfections of the weld shape, as well as other faults empeding control by other methods of non-destructive testing are to be eliminated and the places of corrections are to be repeatedly accepted by the control bodies of the manufacturer of welded structures. The Register retains the right to demand allocation of additional portions to be controlled by appropriate test methods in places where surface defects had been detected by visual examination, thus indicating serious violations in the welding technological process.

3.1.4.3 If the heat treatment of weldments is specified in the procedure, the non-destructive acceptance tests are to be carried out after completion of the heat treatment.

Note. Prior to heat treatment conducted to relieve the residual stresses, it is recommended — and for weldments in special structures manufactured of high strength steels it is considered necessary — to carry out a preliminary check of the welds to find and eliminate the inadmissible faults.

3.1.4.4 The Register may require to repeat the non-destructive tests before commissioning of the welded structures or in the course of the final acceptance procedure, if such structures were subjected to loads unforeseen in calculations for normal operating conditions (for instance, during transportation to the erection site, in tests by proof loads or by pressure exceeding the design service levels). The type and scope of such tests are in each particular case subject to special consideration by the Register.

3.1.4.5 Inadmissible defects discovered at all stages of weld control are to be eliminated without fail. The repeated correction of the same portion of the weld may only be performed with a special permission of the Register. Repair of defects by welding may not, as a rule, be performed more than two times at the same length of the weld.

3.1.4.6 The radiographic and ultrasonic methods of non-destructive testing can be employed either independently or in combinations, as indicated in 3.1.1 and in accordance with the requirements of Tables 3.2.1-1, 3.2.1-2 and with additional explanations given below:

.1 the radiographic and ultrasonic methods are interchangeable, as a rule, within the range of thicknesses from 10 to 40 mm. The lower limit depends on the possibility of use of ultrasonic fault detection for particular type of thin sheet structures (on their accessibility), and the upper limit may be increased essentially when using radiation sources of sufficient capacity and proper procedures of ultrasonic control;

.2 when the ultrasonic fault detection is used on its own, as an independent method of acceptance testing, the welds on primary and secondary structures are to be subjected to additional radiographic control covering at least 10 per cent of the total quantity of weld portions to be controlled;

.3 for welds performed with the use of fluxless welding methods (such as combinations "wire-gas") the main method of control is to be, as a rule, ultrasonic fault detection, with additional radiographic control, as indicated in 3.1.4.6.2;

.4 welded joints made in downward direction must be controlled with ultrasonic fault detection as the main method and radiographic control as an additional method covering 10 to 20 per cent of the total quantity of weld portions to be controlled;

.5 for joints made with the use of welding methods which are potentially dangerous from the point of view of causing 3D defects (such as porosity or slags produced in welding by coated electrodes in the course of installation work), radiographic control is to be used as the main method, or as additional to the ultrasonic method in the scope to be agreed with the Register in each particular case.

3.1.4.7 If in the course of the main or additional control of welded joints in any category of criticality cracks are detected (plane reflectors for ultrasonic control), the following measures are to be taken:

.1 a control opening of the weld is to be done to reveal more clearly the nature of detected faults for their subsequent elimination;

.2 stopping of the welding operations carried out in accordance with the WPS which is thought to be the cause of defects;

.3 revaling and elimination of the causes of crack generation with subsequent submission to the Register surveyor of the exhaustive information on measures taken for their correction;

.4 whenever necessary, introduction of corrections into the welding process specification, submitting again this document for approval by the Register.

When only radiographic method was used for primary (main) control, the Register surveyor may require the use of ultrasonic method for control of additional or already checked portions of the welds.

The decision on resumption of welding operations is taken by the Register surveyor individually under condition that the measures taken by the manufacturer for elimination of crack generation causes can be considered sufficient.

3.1.4.8 If the quality estimates obtained for the same portion of welded joint, while using both radiographic and ultrasonic methods (for instance, on special structures), differ essentially, the following provisions are to be observed:

.1 in case of in-plane defects, such as cracks, incomplete penetrations, lacks of fusion, the sound reason for control opening of the weld and elimination of the detected faults is the conclusion "no-go" made on the basis of the results obtained by any of the methods employed;

.2 in case of 3D defects, such as pores and slags the decision is taken on the basis of radiographic control results. When the radiographic control is used additional checking is performed of two weld portions adjacent to the defective one, plus two additional portions within the technologically independent welded joint, or four small welds (less than 1 m long) within the same section, i.e. two welds immediately before and after the defective portion.

3.1.4.9 If in the course of the main or additional random control of welded joints on primary and secondary structures in-plane defects are detected, such as cracks, incomplete penetrations and lack of fusion, the whole length of the technologically independent welded joint completed by the welder responsible for the defect is to be subjected to checking.

In case of short-length welds (below 1 m) all the joints of the same type within the section or erection joint performed by the same technological process as the faulty weld are to be subjected to checking.

Notes. 1. A technologically independent joint is a weld of continuous length having the same cross-section and edge preparation within this length performed with the use of the same welding technique and the same welding consumables, the same welding conditions in the same or continuously changing welding position.

2. Short-length joints include butt welds on sections and bars (butt weld joints in stiffeners, etc.), as well as T-joints (with full penetration) between pipe branches and flooring, decks and bulkheads.

3.1.4.10 If in the course of the main or additional control of welded joints on primary and secondary structures some inadmissible faults are detected, differing from those indicated in 3.1.4.9, they are to be dealt with using the following additional control procedure:

.1 the control is to be extended to portions adjacent to the faulty one on both sides, until satisfactory results are obtained;

.2 for each weld portion rejected in the course of main or additional control two new portions to be controlled within the same technologically independent joint are to be specified, their location to be agreed with the Register;

.3 for short-length welds it is necessary to check, over their whole length, four similar welds completed by the same welder with the use of the same welding technique: two preceding and two subsequent welds;

.4 if the results of additional control point out to regular emergence of the inadmissible defects, all the technologically independent welded joints, or short-length welds within the section completed by the same welder with the use of the same welding process specification are to be checked over their whole length;

.5 if in the course of the main and additional control 50 per cent or more of the length of a particular technologically independent joint or of a certain number of similar short-length welds within the same section have been checked and it has been found that further checking is required, the joint is to be controlled over the whole length, or all the short-length welds are to be properly checked.

3.1.4.11 The method selected for additional control in accordance with the requirements of 3.1.4.9, 3.1.4.10 is to comply with the nature and predominant orientation of detected faults, also with the possibilities of its application for a particular type of joints. The Register surveyor may require a simultaneous use of both the radiographic and ultrasonic methods for additional control and also, as an alternative, use of special procedures for application of only one method (for instance, sonic testing by the straight beam of the weld with flush finish, sonic testing of welded joints in planes corresponding to the edge preparation, etc.).

3.2 SCOPE OF CONTROL

3.2.1 The welded joints of MODU and FOP structures of all categories are to be subjected to control by visual examination and measurements over the whole length taking into account the provisions of 3.1.4.2. The scope of application of physical methods of non-destructive testing are to comply with provisions of Table 3.2.1-1 for MODU and Table 3.2.1-2 for FOP.

Table 3.2.1-1

Minimum scope of non-destructive testing of welded joints in MODU in per cent of total weld length of structures

Categories of structures[1]	Types of joints	Welded joints in the topside (atmospheric) area				Welded joints in the boot-top (water-wetted) and underwater areas			
		Visual examination	Radio-graphic control[3]	Ultrasonic control[3]	Magnetic particle control[4]	Visual examination	Radio-graphic control[3]	Ultrasonic control[3]	Magnetic particle control[4]
Special structures	Butt joints	100	10	100	20	100	20	100	100
	T-joints		—	100[5]	100		—	100[5]	100
	Fillet joints		—	100[5]	100		—	100[5]	100
Primary structures	Butt joints[2]	100	10	10 — 20[6]	10	100	10	20	20
	T-joints[2]		—	10 — 20[5,6]	20		—	20[5]	100
	Fillet joints		—	10 — 20[5,6]	20		—	20[5]	100
Secondary structures	Butt joints	100	To suit job[7]	To suit job[7]	To suit job[7]	100	5	5	5
	T-joints		—	To suit job[5,7]	To suit job[7]		—	5[5]	5
	Fillet joints		—	—	To suit job[7]		—	—	5

N o t e s . Location of weld portions to be controlled by non-destructive methods in the scope of less than 100 per cent is established by agreement with the Register in each particular case taking into account the requirements of 3.2.2, 3.2.4, 3.2.5, 3.2.6 and 3.2.7.

[1] Requirements for non-destructive testing of welds joining the structures of various categories are to be specified as for the highest category.

[2] Welded joints contributing to the general strength of the structure and becoming inaccessible or hard-to-reach in service is to be subjected to non-destructive control by ultrasonic or radiographic methods over their whole length.

[3] The ultrasonic and radiographic methods of non-destructive testing may be employed as interchangeable and supplementing each other depending on the type of predominant defects and on technical feasibility of method application. In this case the total minimum scope of control effected by both methods is to remain within the values specified in the Table. For instance, for butt joints in special MODU structures submerged in water the total control scope is to be equal to at least 120 per cent.

[4] For nonmagnetic metals the control by capillary methods are to be used.

[5] The ultrasonic control of joints completed with the use of fillet welds, also of T-welds and/or fillet welds with planned incomplete penetration, is to be used in cases of design thickness of the fillet weld exceeding 12 mm.

[6] The following principle of scope control determination is used:
— 10 per cent for joints subjected to static loads in service;
— 20 per cent for joints subjected to changing loads.

[7] Control "to suit the job" means the scope from 0 to 5 per cent, as specified by the Register surveyor or the structure designer.

Table 3.2.1-2

Minimum scope of non-destructive testing of welded joints in FOP in per cent of total weld length of structures

Categories of structures[1]	Types of joints	Visual examination	Ultrasonic and radiographic control[2]			Magnetic partical control[5]
			Total scope	Including		
				Radiographic control	Ultrasonic control	
Special structures	Butt joints	100	120[4]	20 — 100[3]	20 — 100	100
	T-joints		Not specified	—	100[7,8]	100
	Fillet joints		Not specified	—	100[9]	100
Primary structures	Butt joints	100	60[4,10]	10 — 50	10 — 50	50[6]
	T-joints		Not specified	—	20[7,8]	50[6]
	Fillet joints		Not specified	—	20[9]	50[6]
Secondary structures	Butt joints	100	10	5	5	5
	T-joints		—	—	5[8]	5
	Fillet joints		—	—	—	5

Notes:

[1]Requirements for non-destructive testing of welds joining the structures of various categories are to be specified as for the highest category.

[2]The ultrasonic and radiographic methods of non-destructive testing may be employed as interchangeable and supplementing each other depending on the type of predominant defects and on technical feasibility of method application (see 3.1.4.6).

[3]If required by the Register, the scope of the radiographic control of butt joints in the plating elements of special structures may be increased to 100 per cent at the expense of reduction in the scope of ultrasonic control.

[4]For welded joints completed in situ (in the course of FOP installation), also for joints unaccessible in service, the total scope of radiographic and ultrasonic control may be increased, by request of the Register, to 150 per cent for joints in special structures and to 120 per cent for primary structures (keeping in mind Note 1).

[5]For nonmagnetic metals the control by capillary methods is to be used.

[6]If required by the Register in compliance with provisions of 3.2.4, also at the beginning of the welded structures manufacture, the scope of magnetic particle testing can be increased to 100 per cent of the weld joint length.

[7]For cruciform joints in special and primary structures the ultrasonic control of base metal continuity throughout the thickness is to be used. The control is to be effected prior to and after welding in the scope from 20 per cent to 100 per cent depending on the quality of the base metal and degree of structure criticality.

[8]For T-joints the ultrasonic control is to be effected:
— with guaranteed full penetration: irrespective of metal thickness;
— with full non-guaranteed penetration: at thickness of parts to be welded-on exceeding 12,5 mm;
— with planned incomplete penetration: at thickness of parts to be welded-on exceeding 15,0 mm.

In the last case it is permitted, by agreement with the Register, to control only the presence of cross cracks in the weld and zone adjacent to the weld.

[9]The ultrasonic control method is to be used for checking of fillet welds executed without grooving at design thickness of the fillet weld >10 mm. In this case it is permitted, by agreement with the Register, to control only the presence of cross cracks in the weld and zone adjacent to the weld.

[10]The total scope of control of butt welds in the primary structures can be reduced, by agreement with the Register, down to 20 per cent, if the quality of welds appears to be stable. In this case the reduction of control scope can be random, electing the welding technological processes with the level of defects as estimated by photographs not exceeding 5 per cent.

3.2.2 As a rule, subjected to non-destructive testing are to be intersections of butt joints, cruciform joints and other joints located in zones with high level of stresses, also spots of beginning and ending of automatic welding and zones where the visual examination caused some doubts.

3.2.3 When controlling intersections of butt welds by radiographic methods (keeping in mind provisions of 3.2.2), the photograph is to be held symmetrical to the axis of the weld to be controlled, so that it could partly cover the second weld (within the frame width).

At random ultrasonic control of butt welds' intersections one is to cover portions of 100 mm width on both sides of the weld under control in the place of its intersections.

3.2.4 The scope of weld control by radiographic or ultrasonic methods for prototype objects built by the manufacturer, as well as in the course of repair, modernization and conversion, may be brought up from the values given in Table 3.2.1, if requested so by the Register or the designer of the object.

3.2.5 When structural elements are welded into a rigid contour structure (cutouts where the relation of the minimum cutout size to the plating thickness is below 60), the butt and T-joints in special and primary structures are to be controlled over the whole their length and in secondary structures over at least 20 per cent of the length with the use of radiographic or ultrasonic methods by agreement with the Register.

3.2.6 The control of weld in structures to be subjected to treatment by pressure (bending, forming, etc.) by radiographic or ultrasonic methods is to be carried out over the whole length of welded joints in such structures after treatment by pressure.

If the above structures are subject to heat treatment after the pressure treatment, the radiographic or ultrasonic testing is to be performed after the heat treatment.

3.2.7 In technically feasible cases, such as welding of joints with thickness of 20 mm and above performed by automatic submerged arc welding machines, the Register may require ultrasonic control of special and primary structures over the whole weld length for detection only of cross cracks in the weld and zone adjacent to the weld.

3.2.8 The welded joints where stresses throughout the thickness can emerge are to be subjected to ultrasonic control aimed at detection and estimation of discontinuities in the base metal after completion of the welding.

The documentation for ultrasonic control of the base metal in the zone adjacent to the weld is to be approved by the Register individually on the basis of the respective test results.

3.2.9 Non-destructive testing of welds completed underwater is considered by the Register separately in each particular case. The scope of such testing is subject to special consideration.

3.3 EVALUATION OF WELDED JOINT QUALITY

3.3.1 The criteria for evaluation of welded joint quality in structures of MODU and FOP are to comply with the requirements of norms and standards agreed with the Register, as well as with the requirements of 3.3, Part XIV "Welding" of the Rules for the Classifications and Construction of Sea-Going Ships. Unless otherwise specified, the quality of welded joints is to meet the requirements of Table 3.3.1.

Table 3.3.1

Categories of structures	Least acceptable point	
	in 5-point system[1]	in 3-point system[2]
Special	2	III
Primary	2	III
Secondary	3	II

[1]According to the accepted standards.

[2]According to 3.3.2, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

4 WELDING CONSUMABLES

4.1 GENERAL

4.1.1 For welding of MODU and FOP structures only welding consumables approved by the Register and produced by manufacturers recognized by the Register may be used.

General regulations on acceptance of welding consumables and methods of testing depending on welding technology are selected in accordance with Section 4, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

4.1.2 When accepting welding consumables for welding of steels with thickness of 50 mm and more intended for use in special structures, tests are to be carried out confirming the resistance of weld metal and welded joint to brittle fracture at temperatures indicated in 1.4, Part XII "Materials" of MODU/FOP Rules.

The procedures, scope, conditions and criteria for estimation of the results of such tests are to be agreed with the Register in each particular case.

4.1.3 The ultimate rupture strength of the welded joint is not to be below ultimate rupture strength of steel employed in the respective structural element.

For the weld metal and heat-affected zone the value of impact strength and test temperature is to be similar to those required for the base metal.

4.1.4 The electrodes, combinations wire-flux and wire-gas intended for welding of special and primary structures made of higher- and high-strength steels are to ensure the content of diffusible hydrogen in the deposited metal corresponding to indices HH or HHH. Only electrodes with basic coating are to be used for the purpose.

For welding of secondary structures with thickness up to 20 mm not subjected to dynamic loads electrodes with rutile coating may be used.

4.2 ADDITIONAL REQUIREMENTS FOR WELDING CONSUMABLES

4.2.1 The welding consumables utilized in manufacture of special and primary structures with thickness exceeding 30 mm may be subjected, on request of the Register, to tests for determination of crack resistance parameter CTOD in accordance with the regulations given below.

The CTOD testing of butt weld metal may be conducted as additional tests for initial granting of the Type Approval Certificate for welding consumables. If the manufacturer of welding consumables omitted such tests or conducted them at lower than specified base metal thicknesses, then such test is to be performed at the stage of approval of welding procedures by the Register.

4.2.2 When imposing requirements upon the crack resistance parameter CTOD of the weld, the minimum quantity of correct specimens tested at design service temperature T_d is to be at least three. The value of CTOD defined as the mean of three test results is to be not lower than values given in Table 4.2.2-1, if the material is used for welding special structures and not lower than values given in Table 4.2.2-2, if the material is used for welding primary structures.

.1 when testing three correct specimens neither of the results obtained are to be lower than 70 per cent of the mean value;

.2 when testing five or more correct specimens the minimum result obtained may be reduced to 50 per cent of the mean value.

For metals of weld joints exceeding 70 mm in thickness the possibility of their use for special and primary members is defined with the aid of procedures agreed with the Register and intended for

Table 4.2.2-1

Thickness not more than, mm	Strength group							
	norm.	Y32 and Y36	Y40	Y42	Y46	Y50	Y55	Y62	Y69
40	—	0,10	0,10	0,10	0,10	0,15	0,15	0,20	0,20
50	0,10	0,10	0,15	0,15	0,15	0,20	0,20	0,20	0,25
70	0,10	0,15	0,20	0,20	0,20	0,20	0,25	0,25	0,30

Table 4.2.2-2

Thickness not more than, mm	Strength group								
	norm.	Y32 and Y36	Y40	Y42	Y46	Y50	Y55	Y62	Y69
40	—	—	—	0,10	0,10	0,10	0,10	0,15	0,20
50	0,10	0,10	0,10	0,15	0,15	0,15	0,20	0,20	0,25
70	0,10	0,15	0,15	0,15	0,20	0,20	0,20	0,20	0,25

calculation of brittle fracture resistance, using as the basis of specially determined fracture toughness characteristics K1c or J1c.

4.2.3 The CTOD testing of welded joint metal is carried out in accordance with 2.2, Part XII "Materials" of MODU/FOP Rules with subsequent supplements:

4.2.3.1 Types of specimens:

.1 rectangular cross-section specimens tested by three-point bending;

.2 square cross-section specimens tested by three-point bending;

.3 compact specimens tested by eccentric tension.

Specimens orientation within the sample is to meet the requirements of the Register.

When checking the welded joint with thickness up to 50 mm and with the crack propagating along the weld axis, it is recommended to use rectangular cross-section specimens. When the crack is propagating across the weld, the square cross-section specimens are more suitable. The thickness of the specimens is to be, as far as possible, close to the thickness of actual welded joint. For thicknesses above 50 mm use of compact specimens is recommended. The thickness of compact specimens must be selected as close as possible to a particular welded joint thickness within the following dimensional range: 50 mm, 75 mm, 100 mm.

4.2.3.2 When defining the crack resistance of welded joint metal the notch is to be arranged so that the tip of the crack over the largest possible length of its front was located within the welded joint zone specified by the Register (centre of the weld, metal adjoining the fusion line, etc.). The technological parameters of welding procedure and type of edge preparation are to comply with the type of welded joint to be checked. Before marking out and cutting of the notch it is necessary to carry out etching and study of the metal inner structure. The accuracy of obtained results is to be ensured by larger quantity of test specimens (up to 8 to 10 per one test temperature) and by rejection after testing of those specimens where the crack propagated beyond the limits of the zone under study.

4.2.3.3 It is permitted to test specimens cut out of welded blanks with angular deformations after straightening. The straightening is carried out in the same way, as on base metal specimens.

4.2.3.4 For specimens with residual welding stresses and specimens subjected to straightening it is permitted to release the residual stresses by mechanical methods. The recommended method of mechanical stress release is described in 2.2, Part XII "Materials" of MODU/FOP Rules.

4.2.3.5 For testing with notch location within the line of fusion or some other suitable microstructure it is considered sufficient, if in the initial fatigue crack front there is a portion of suitable microstructure of about 15 per cent specimen thickness length, unless otherwise specified by the Register. For testing with the notch located in the weld centre it is considered sufficient to have 70 per cent of weld metal within the initial crack front.

PART XIV. AUTOMATION

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of Sections 1 to 5 and 8 to 10 apply to automation equipment subject to supervision irrespective of whether the MODU or FOP has an automation mark in its class notation or not.

The requirements of Sections 6, 7 apply to units which, in conformity with 2.4, Part I "Classification", have the automation mark **A** and/or one of the marks **ДИНПОЗ** added to the character of classification, with indication of the appropriate class of the dynamic positioning system according to 7.1.2.

The requirements of Section 6 are applicable also to the units which have no automation mark in the class notation but provided main machinery control room and remote control and monitoring systems of the machinery and devices.

1.1.2 The present Part of the Rules contains technical requirements for the automation equipment listed in 1.1.1 and defines the minimum needed extent of remote automated control, protection, alarm and indication.

1.1.3 For units with nuclear power plants, the level of automation to grant the automation mark in the class notation is subject to special consideration by the Register.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 Definitions and explanations relating to the general terminology of the Rules are given in Part I "Classification"of MODU/FOP Rules.

For the purpose of this Part the following definitions have been adopted.

A u t o m a t e d p l a n t is a complex of machinery and equipment fitted up with automation systems or devices to enable a remote automatic or automated control and monitoring of the plant.

U n i n t e r r u p t i b l e p o w e r s u p p l y is a mode of the electrical power supply achieved through combined operation of the main, emergency and standby sources of electrical power, to enable the continuity of power supply to be maintained in case of the main power source failure.

A c k n o w l e d g e m e n t is manual confirmation of receipt of an alarm or call.

A u t o m a t i o n e q u i p m e n t includes instrumentation, sensors, actuators and other equipment intended for the automatic or remote automated control, protection and alarm, i.e. for remote monitoring of machinery and installations.

C o n t r o l a n d m o n i t o r i n g s t a t i o n is a special space or area containing control and/or monitoring means intended for:

control and monitoring of propulsion plant or dynamic positioning system of the MODU;

electric generating plant;

control and monitoring of an emergency electric generating plant;

control and monitoring of other machinery, systems and facilities supporting functioning of the MODU or FOP under normal or emergency conditions, for example, shut-down system of the industrial equipment, remote and emergency shut-down system of the machinery, radio communication and internal loudspeaking communication systems and command telephony system, etc.

S t a n d b y p o w e r s o u r c e is a source of electrical power independent of the main and emergency power sources. The standby power source may be used to provide uninterrupted power supply to certain kinds of essential equipment.

R e m o t e a u t o m a t e d c o n t r o l s y s t e m is automation 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 actuating devices realizing the mode of the machinery functioning set up by the operator.

A l a r m s y s t e m is an apparatus to release visual and audible signals simultaneously in order to attract attention of the personnel and oblige them to take certain actions. The alarm system of a machinery plant is intended to inform the personnel whenever the controlled parameters reach the preset limits and deviations of machinery and associated systems from normal working ranges occur.

C o m m o n a l a r m s y s t e m is a part of the alarm system in which individual alarm signals are combined to generate a single common signal at the main remote control station and/or in the public and accommodation spaces. Each common signal is to have a notation to describe the common signals, for example, "Parameters of the electric generating plant", "Parameters of the boiler plant", etc.

Safety system is equipment to automatically actuate, 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 or on the fluctuations of certain conditions in machinery and devices

Automation device is a part of automation system comprising elements which form a structural and functional unity.

Automation component is a structurally independent item (e.g. amplifier, sensor, relay, logic element) used in control devices and automation systems.

1.3 SCOPE OF SUPERVISION

1.3.1 General provisions concerning classification procedure, supervision of MODU or FOP during design or construction, manufacture of equipment and component thereof, surveys and requirements for technical documentation to be submitted to the Register for consideration and approval on the MODU or FOP as a whole are to be found in Part I "Classification" of MODU/FOP Rules and General Regulations for the Classification and Other Activity.

1.3.2 Subject to supervision during manufacture, as well as on board the MODU or FOP are automated control and monitoring systems and devices of the following:

.1 machinery and propellers of the propulsion plant, thrusters and steering gears of self-propelled MODU;

.2 apparatus and other equipment of electric generating plants;

.3 driving machinery of generators and converters;

.4 driving machinery of jacking arrangements of self-elevating MODU;

.5 ballast systems for raising and descending of submersible and semi-submersible MODU;

.6 windlasses, winches and other deck machinery;

.7 auxiliary machinery (pumps, compressors, etc);

.8 main and auxiliary boilers;

.9 refrigerating plants;

.10 alarm system, fire detection system, etc;

.11 MODU draught, heel, trim, etc measuring and logging systems;

.12 other systems as required by the Register.

1.4 TECHNICAL DOCUMENTATION

1.4.1 has been amended to read:

"**1.4.1** For each item of automation equipment listed under 1.3.2, the following technical documentation is to be submitted to the Register:

.1 functional description including technical parameters and operating conditions (explanatory note);

.2 block diagrams of control and monitoring systems;

.3 plans of front panels of control consoles with indication of functional components;

.4 general view drawing (layout of basic components);

.5 list of controlled parameters of the unit for alarm system and common alarm subsystem;

.6 description of power supply sources for automation system and their connection diagram;

.7 guidelines for installation and operation;

.8 cable routing layout drawing and means of protection against electromagnetic interference;

.9 test program and test standards;

.10 failure mode-and-effects analysis (for complicated automation systems, such as Class 2 and 3 dynamic positioning control systems or integrated computer-based systems);

.11 documentation on software and information on testing thereof by the builder.

2 DESIGN OF AUTOMATION SYSTEMS

2.1 GENERAL

2.1.1 The design of automation components and control devices is to ensure an average operating life of automation systems between repairs of at least 5000 h.

2.1.2 Reliable operation of automation systems, automation components and control devices is to be ensured under the following ambient temperature conditions:

0 °C to +45 °C in enclosed spaces;

-25 °C to +45 °C on open decks.

Electronic elements and devices to be fitted in switchboards, control consoles or individual enclosures are to operate reliably at ambient temperatures up to 55 °C.

No damage to automation systems, automation components and control devices is to be caused by temperatures up to 70 °C.

2.1.3 Reliable operation of automation systems is to be ensured at relative air humidity of 75 per cent and temperature of 45 °C or at relative air humidity of 80 ± 3per cent and temperature of 40 ± 2 °C, as well as at relative air humidity of 95 ± 3 per cent and temperature of 25 ± 2 °C.

2.1.4 Reliable operation of automation systems is to be ensured at vibrations having a frequency of 2 to 100 Hz, namely, with a shift amplitude of ± 1 mm where the vibration frequency is between 2 and 13,2 Hz, and with an acceleration of 0,7*g* where the vibration frequency is between 13,2 and 100 Hz.

Reliable operation of automation systems installed on vibration sources (diesels, compressors, etc) or in steering is to 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 4,0*g* where the frequency is between 25 and 100 Hz.

Besides, automation equipment is to operate reliably under shocks having an acceleration of 5,0*g* and frequency between 40 and 80 shocks per minute.

2.1.5 Reliable operation of automation systems is to be ensured at long-term heel up to 22,5° and at motions of 22,5° with a period of 8 ± 1 s.

2.1.6 The protection of enclosures of the automation systems, automation components and control devices is to be chosen in accordance with 2.4, Part X "Electrical Equipment" of MODU/FOP Rules.

2.1.7 Electrical and electronic components and devices are to operate reliably in case of deviation of the power parameters listed in Table 2.1.7 from nominal values.

Automatic equipment supplied from accumulator batteries is to operate reliably with the following voltage variations from the nominal value:

from +30 to −25 per cent for the equipment which is not disconnected from the battery during battery charging;

from +20 to −25 per cent for the equipment which is disconnected from the battery during battery charging.

The operability of automation systems is not to be affected by a loss of power supply repeated three times at an interval of 30 s.

Table 2.1.7

Parameter	Deviation from nominal value		
	long-term	short-term	
	per cent	per cent	S
Voltage	+6 to −10 *	±20	1,5
Frequency	±5	±10	5

* For direct current: ±10 per cent.

2.1.8 Pneumatic and hydraulic components and devices are to be operable under fluctuations of the working medium pressure within ±20 per cent of the nominal value.

2.1.9 Provision is to be made to ensure the electromagnetic compatibility of automation equipment (see 2.2, Part X "Electrical Equipment" of MODU/FOP Rules) and to keep the radio interference from it to a permissible level.

2.1.10 Automation equipment is to operate reliably in the event of harmonic distortions of the supply voltage curve as specified under 3.2.1.5, Part X "Electrical Equipment" of MODU/FOP Rules.

2.1.11 Components and devices to be installed in locations with specific operating conditions (high or low temperature, excessive mechanical loads, etc.) are to be designed and tested with regard for these conditions.

2.1.12 For sensors intended to measure the temperature of media under pressure, provision is to be made for pockets the strength of which is to be designed for the maximum pressure like the casing or piping of the equipment where the sensor is fitted.

2.1.13 Three-way valves or similar devices are to be fitted on the measuring pipes before the sensors to enable functional check of the sensors without dismounting thereof and for blowing off. Access to operations with these valves is to be possible only for authorized personnel with the use of special tool.

2.1.14 Provision is to be made that in case of failure of visual or audible alarm devices in one circuit the functioning of the remaining circuits would not be affected.

2.2 REQUIREMENTS FOR COMPONENTS AND DEVICES

2.2.1 The components and devices used in the automation systems are to be so constructed as to permit easy mounting, adjustment and replacement thereof. Screwed joints are to be provided with means to prevent them from being worked loose. No mechanical resonance with an amplification factor in excess of 5 is permitted

2.2.2 Pneumatic and hydraulic components and devices are not to be damaged by momentary overloads due to a working medium pressure rise equal to 1,5 times the working pressure.

2.2.3 The contacting surfaces of electric plug-in-socket connections are to be so designed and positioned as to prevent the increase of contact resistance restricting their performance.

2.2.4 Cable inlets to cabinets or connection boxes in machinery spaces are to be arranged on the underside or side of the cabinets or boxes. Where cable inlets are arranged on the side, the cable is to have a loop directed downwards. Cable inlet from above is only permitted through tight glands or special arrangements to prevent penetration of liquids into the item concerned. At cable inlets, especially in way of connection to movable components and devices, provision is to be made to avoid tension effects.

2.2.5 Printed circuit boards are to be coated with insulating varnish over the connecting wire line.

2.2.6 Regulating components intended for initial setting are to be protected against spontaneous change of setting.

A reset and fixing of the regulating components is to be possible.

2.2.7 Servomotors are to be so constructed that no spontaneous uncontrolled change of their setting is possible.

2.2.8 All units, terminal boards, cable connections and test points on the components and devices are to be clearly marked. The marking of sensors, logic units and actuators is to contain information on their functionality so that they can be identified on the drawings and in the lists of devices and systems.

2.2.9 Information (signalling) circuits are to be so constructed as to preclude damage to the unit or associated components in case of their malfunction. No damage to the unit or adjacent component is to occur in case of short-circuit, earth fault or break-off of line transmitting signal from the measuring element to other devices. Such malfunctions are to result in relatively safe condition of the module or component with an alarm signal being released.

2.2.10 Pipes of the hydraulic and pneumatic automation devices are to be of metal. Plastic pipes are accepted in the pneumatic devices provided they meet the following requirements. Pipes and other equipment made of plastic materials are to have satisfactory mechanical strength, low thermoplasticity, high oil and fire resistance. These properties are to be supported by appropriate tests.

2.3 GENERAL REQUIREMENTS FOR AUTOMATED CONTROL SYSTEMS OF MACHINERY AND PLANTS

2.3.1 Replaceable and adjustable components as well as check-up points (terminals, monitoring jacks) are to be so arranged that easy access is possible at any time.

2.3.2 Provision is to be made to prevent incorrect mounting while replacing removable items (modules) having plug-in-socket connections and to ensure their efficient fixing in the working position. Where necessitated by the operating or structural features of components and devices, their position assuring proper mounting is to be clearly marked or, alternatively, they are to be so constructed that the possibility of being mounted in a wrong position is excluded.

2.3.3 Devices are to be so constructed as to permit check measurements to be taken while in operation.

2.3.4 The automation control systems are to be so constructed that the replacement of components and devices by others of the same type would not affect the operation of the systems or require additional adjustment. The adjustment, if necessary, is to be possible with simple means.

2.3.5 Electrical and electronic automation systems are to be fitted up with protective devices capable of selective disconnection of that part of the system where a fault occurs.

2.3.6 Automation control systems are to be based on "fail-safe" principle.

2.3.7 Where machinery or plants are stopped by safety devices, they are not to be restarted automatically or remotely before a manual reset has been carried out. Any other solution is subject to special consideration by the Register.

2.3.8 The fluids of hydraulic systems are to maintain their physical properties for a long time under all possible operating conditions, are to possess good lubricating properties and a vapour flash point not less than 60 °C, are not to cause the damage to components and piping and not to be toxic.

2.3.9 It is to be possible to clean the filters while in operation.

2.3.10 Hydraulic automation control systems are not to communicate with other control systems and are to be supplied from separate tanks. In exceptional cases and on agreement with the Register, the use of fluid from other systems may be permitted for actuating devices subject to the provision of cleaning arrangements.

2.3.11 The feeding pipes from the tanks for hydraulic devices are to be located in the lower parts of the tanks to allow for a level variation due to consumption of fluid and motions of the units in order to avoid formation of air locks.

2.3.12 Pneumatic automation control systems are to have arrangements to ensure the required degree of cleaning and allowable air humidity.

2.3.13 Pneumatic automation systems of the main power plants and electric generating plants are generally to have two devices for cleaning and drying the air so interconnected 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 interrupting the air supply.

2.3.14 The feeding pipes of pneumatic automation control systems are to be fitted up with safety valves set to operate when the nominal working pressure is exceeded by more than 10 per cent. Reducing valves, if any, are to be duplicated.

2.3.15 Where hydraulic, pneumatic and electric or electronic components and devices are combined in desks, cabinets or cubicles, they are to be effectively separated so that eventual leaks from pipes and hoses or from the connections of same would not damage such components and devices.

Desks, cabinets and cubicles accommodating equipment which contains working fluid are to be fitted up with appliances for retrieval of the leaks.

2.3.16 A full or partial loss of power in automated or remote control circuits is not to result in dangerous situations.

2.3.17 The operation of air-cooled control devices is not to be impaired owing to an eventual contamination of cooling air. Where forced cooling is applied, provision is to be made to prevent failure of the air-cooled equipment in case the cooling system fails and to give a proper alarm signal.

2.4 ALARM, SAFETY, INDICATION AND LOGGING SYSTEMS

2.4.1 Alarm system.

2.4.1.1 The alarm system is to be independent of control and safety systems, that is, it is not to be affected by malfunction or failure of such systems.

Possibility of partial integration of these systems is subject to special consideration by the Register in each case.

The alarm system the central panels of which are generally located in the main machinery control room is to have structurally a common alarm subsystem the units (CAU) of which are to be located in:

machinery spaces (visual display units);

navigating bridge (wheelhouse);

service and public spaces;

accommodation spaces for essential personnel (chief engineer, watchkeeping engineers, electrical officer, etc.).

2.4.1.2 Provision is to be made for the self-monitoring of the alarm system; the alarm signal is to be applied in the event of at least such typical faults as short-circuits, circuit break-off and earth fault.

2.4.1.3 The alarm system is to give visual and audible signals simultaneously.

In this case the possibility of simultaneous indication of more than one fault is to be provided.

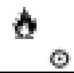
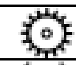
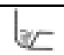
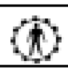
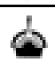
The acknowledgement of one signal is not to prevent acknowledgement of another. Failure of one component (device) of the system is not to cause failure of the alarm system in general. When common monitors are applied instead of individual light signalling devices, at least two such monitors are to be provided.

2.4.1.4 The visual signals in the main macinery control room and at the local control stations are to be individual and indicate the fault condition. They are to be generally given as flashing lights. After being accepted (acknowledged), the flashing light is to change to steady light.

Cancelling of a visual signal is to be only possible after the fault has been repaired or the faulty part of the system disconnected.

2.4.1.5 For all alarm systems, common audible signal devices may be used but not less than two. Once acknowledged, the audible signal is to be silenced, whereupon the system is to be immediately open to forthcoming signals even though the previous faults might not yet be attended to. Simultaneously with acknowledgement of the audible signal in the main machinery control room, audible and visual signals in machinery spaces and on the common signal units in the accommodation and public spaces are to be silenced. However, acknowledgement of the alarm signal on the common signal units at the main machinery control room and in the accommodation spaces is not to bring about silencing of the sound signal in the main machinery control room and/or in the machinery space. In machinery spaces along with the audible signal devices of the alarm system provision is to be made for visual display units (indicator columns) for the identification of the signal, for which colors and symbols shown in Table 2.4.1.5 are to be used. The flashing alarm shall be illuminated for at least 50 per cent of the cycle and have a pulse frequency in the range of 0,5 and 1,5 Hz. The audible signal of the alarm system in machinery spaces is to be clearly heard even though one of signal display units fails.

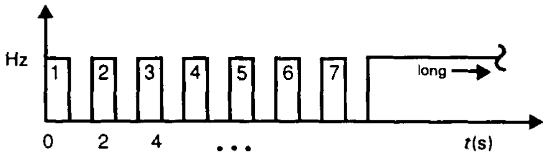
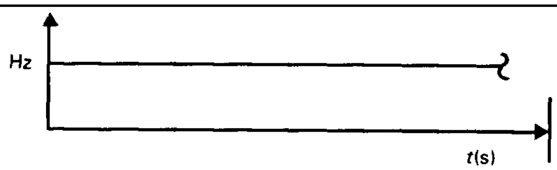
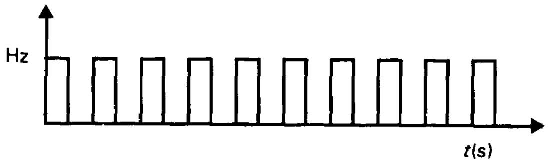
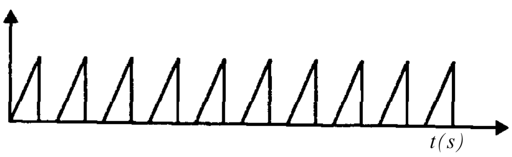
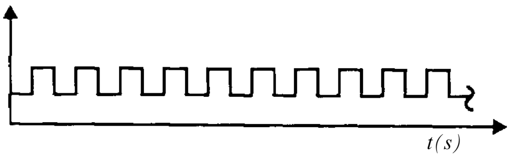
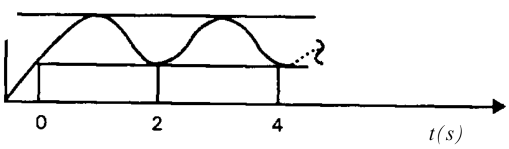
Table 2.4.1.5

Signal	Color	Symbol
Fire detection alarm in spaces other than machinery spaces	Red	
Fire detection alarm in machinery spaces	Red	
Fire extinguishing medium release alarm	Red	CO_2HALLON
Machinery alarm	Yellow	
Steering gear alarm	Yellow	
Bilge alarm	Yellow	
Engineer's alarm	Yellow	
Telephone	White	
Engine room telegraph. Command transmission	White	

2.4.1.6 Self-eliminating faults are to be indicated by the alarm system in such a way that the signal remains applied until it is accepted (acknowledged). The audible signals of the alarm system are to be readily distinguishable from audible signals of other systems. The audible signals (except for the bell) are to 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 system is to correspond to the one of the waveforms shown in Table 2.4.1.6. The sound pressure level at a distance of 1 m from the sound source is to 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 in the engine room. The sound pressure level in a space is not to exceed 120 dB. The sound pressure level is to 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 are to be installed.

2.4.1.7 The signal indicating a complete or partial disablement of the alarm system is to be readily distinguishable in the main machinery control room from other signals. Visual signals and/or indication of

Таблица 2.4.1.6

Nos	Wave form	Comments
1.1		- general alarm
1.2	Special alarm signals	- fire detection alarm in spaces other than machinery spaces
2		- fire detection alarm in spaces other than machinery spaces; - fire detection alarm in machinery spaces; - fire extinguishing medium release alarm; - engine room telegraph (command transmission)
3.1		- alarm system signal; - steering gear alarm; - bilge alarm; - engineer's alarm; - telephone; - engine room telegraph (command transmission);
3.2		- alarm system signal; - steering gear alarm; - bilge alarm; - engineer's alarm;
3.3		- alarm system signal; - steering gear alarm; - bilge alarm; - engineer's alarm;
3.4		- alarm system signal; - steering gear alarm; - bilge alarm; - engineer's alarm;

parameters in computer-based alarm systems are not to be lost due to instantaneous supply voltage drops or mains voltage and frequency fluctuations.

Provision is to be made for structural means of protection against unpredictable or unauthorised intervention that can result in changes to the programs or the limiting values of the controlled parameters (settings).

2.4.1.8 Checking of the alarm system for good working is to be possible while in operation.

2.4.1.9 Momentary power failure in the alarm system is not to bring about the loss of signals applied at the moment.

2.4.1.10 Irrespective of the extent of automation and the surveillance procedure adopted for the machinery, the alarm system is to give warning signals at:

.1 parameters reaching predetermined limit values;

.2 operation of protective 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 are to be provided on the panels from which the machinery is remotely controlled.

2.4.1.11 The alarm system is to be so arranged that signals pertinent to machinery or electric power plant are in the first place relayed to the panels (consoles) in machinery spaces and main machinery control room, as well as to common signal and indication units in the accommodation, service and public spaces in which the personnel attending to the machinery plant may be staying. Then, if the signals are not acknowledged within a specified period of time (e.g. 2 min), they are to be relayed to the main control and monitoring station of the MODU or FOP.

2.4.1.12 Alarm systems are to comprise arrangements to preclude false alarms from momentary changes of parameters due to motions of the unit, starts and stops of machinery, etc.

2.4.1.13 Engineers' alarm.

Provision is to be made for a alarm system to call the personnel attending to the machinery plant to the engine room or main machinery control room, which is to be put into operation:

.1 manually from the main machinery control room or from a local control station of main machinery;

.2 automatically where an alarm for the machinery plant is not acknowledged on the panel in the engine room or in the main machinery control room within a specified period of time (e.g. 2 min).This signalling system is to be led to the common signal units in the accommodation, service and public spaces in which the personnel attending to the machinery plant may be staying.

2.4.1.14 Alarm "Personnel in machinery space".

For periodically unattended machinery spaces provision is to be made for an alarm "Personnel in machinery space" by which the safe and efficient condition of the engineer on duty who is in the machinery space alone is confirmed at the main control station.

Unless reset in a period not exceeding 30 min, this alarm system is to be put in operation:

.1 manually by the engineer on duty when attending machinery spaces on routine checks and is to be disabled after leaving the machinery space;

.2 automatically when the engineer on duty has to attend machinery space in case of a machinery alarm. Disablement of the alarm "Personnel in machinery space" is not to be possible before the engineer has acknowledged the alarm in the machinery space.

A pre-warning signal is to be provided in the machinery space, which operates 3 min before the above alarm is given to the main control station, concerning the necessity of early acknowledgement of the above alarm to be effected by the end of specified (e.g. 30 min) period during the whole time the engineer on duty is staying in the machinery space.

2.4.2 Safety systems.

2.4.2.1 The safety systems of automated machinery are to be provided for those parameters only the deviation of which could lead to serious damage, complete breakdown or explosion. A safety system is to include an indicator to show the parameter for which the system was put into operation.

2.4.2.2 Safety systems are to 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.

2.4.2.3 Where overriding arrangements to make the safety system inoperative are provided for certain parameters, these are to be such as to preclude inadvertent operation. Visual signal is to be provided on the machinery control panels to indicate when the override has been activated.

2.4.2.4 Provision is to be made for self-monitoring of the safety systems; at least at such faults as short-circuit, circuit break-off and earth fault an alarm signal is to be activated.

2.4.2.5 The safety systems of particular machinery and plants are to 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 or plants.

2.4.2.6 The safety system is to be activated automatically at faults that could involve an emergency condition of machinery or plants in order to:

.1 restore normal operating conditions (by starting standby units);

.2 temporarily adjust the operation of machinery to the prevailing conditions (by reducing the load upon the machinery);

.3 protect machinery or plants from emergency condition by shutdown the machinery or plants and shutting off fuel supply thereto.

An alarm signal is to be given before the safety system has been automatically activated.

2.4.2.7 After activation, the safety system is to be brought again to the state of readiness by the personnel. Any other mode of reset is subject to special consideration by the Register.

2.4.2.8 Pressure vessels, boilers and similar installations the breakdown of which can result in explosions, fires, etc, are to have two-level protection from excessive pressure. Such protection is to be provided by various types of safety devices; for example, the first level may be provided by an electrical safety system and the second level — by a safety valve.

2.4.3 Indication and logging systems.

2.4.3.1 Indication and logging systems are to be independent of control, alarm and safety systems so that their failure would not affect such other systems.

2.4.3.2 When logging systems fail, an alarm signal is to be activated.

2.4.3.3 Provision is to be made for easy reading of indicated data with regard for the illuminance at the indicator positions.

2.4.3.4 Provision is to be made for displaying the readings of indication systems in units normally used for the parameters, i.e. without recalculation.

2.4.3.5 The number of devices and displays of the indication system is to be sufficient to enable safe control of the machinery and plants.

3 SUPPLY OF AUTOMATION SYSTEMS

3.1 GENERAL

3.1.1 Where the essential machinery or plants are supplied from both main and emergency power sources, the automation systems or devices of these machinery or units are also to be supplied from the said two power sources. Consumers differing in voltage are to be supplied by separate feeders.

3.1.2 The control systems of propulsion plants are to be supplied by two separate feeders, one of which is to take power from the main switchboard and the other may be connected to the switchboard for essential services or, by way of exception, to the nearest switchboard. The change-over from the main feeder to the standby one is to be effected automatically with appropriate signal activated at the control station.

3.1.3 Where the automation systems of particular auxiliary machinery are supplied by the same feeders as the corresponding electric motors, provision is to be made for a start of standby auxiliary machinery and for connection of the automation system to its feeder in the event of blackout in the power circuit of the running machinery.

3.1.4 Hydraulic and pneumatic automation systems are to be supplied from two sources. The second source is to be connected automatically upon pressure loss with release 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 2.3.15, 2.3.16 are complied with.

3.1.5 Air used for the automation system is to be free from oil, moisture and other contamination. To avoid condensate formation, provision is to be made for heating arrangements or other means to preclude formation of condensate over the entire range of working temperatures.

3.1.6 Alarm and safety systems are to be supplied from both main and standby sources. The standby power source is to be an independent source (e.g. an accumulator battery) which is to come into operation automatically when the main source fails, with an alarm activated upon change-over.

The capacity of the standby source of power is to be sufficient for powering the automation and safety systems during 30 min.

3.1.7 The driving machinery of generators is to be supplied independently of the main switchboard busbars.

4 AUTOMATED MACHINERY AND PLANTS

4.1 GENERAL

4.1.1 Machinery and plants are to be constructed in conformity with the applicable requirements of the relevant Parts of the Rules, and provision is to be made for local stations and alarm devices and indicators.

4.1.2 Machinery and plants which can be started automatically or remotely are to 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 to be still possible.

4.1.3 Change over from local control to automatic or remote control is to be possible from local control stations only. Change over from remote to automatic control may be effected from remote control stations.

4.1.4 If the preset sequence of operations is disturbed, the programmed automatic control system is to stop performing the program and is to bring the machinery to a safe condition with an alarm released in all cases at the control station where continuous watch is kept.

4.1.5 Where a fuel gas system is provided to feed the electric power plant, provision is to be made for an interlocking between the gas supply system and the ventilation system of the gas pipeline protective casing. When gas is supplied to the gas pipeline , the ventilation of the protective casing is to be switched on and a gas concentration sensor is to be provided at the ventilation duct outlet to detect possible leakages.

4.1.6 Gas fuel supply is to be automatically terminated when:

gas with a concentration of 60 per cent of the lower inflammability level is detected in the casing to be ventilated;

gas with a concentration of 25 per cent of the lower flammable limit is detected in the machinery space;

ventilation of the gas pipeline protective casing is stopped;

a fire is detected in the machinery space.

4.2 AUTOMATED PROPULSION PLANTS

4.2.1 The remote control system of the propulsion plant of the MODU is to provide start and stop, as well as the control of the propeller speed, thrust value and direction of rotation within the whole permissible operating range of the propulsion plant.

4.2.2 The remote control system is to meet the following requirements:

.1 in case of quickly alternating commands, the last one in a sequence is to be executed irrespective of the operating condition;

.2 setting of the speed or of the thrust value and direction of rotation is to be effected by means one and the same control unit;

.3 when setting the speed of the propulsion plant, provision is to be made for an automatic passing of the critical rotational speed ranges irrespective of the preset operation mode;

.4 remote control systems and engine telegraph systems are to be independent of each other so that faults in one of the systems would not affect the operation of the other; for both systems one and the same control unit may be used;

.5 provision is to be made for signalling to indicate power loss and malfunction of the remote control system;

.6 for propulsion machinery which are served by independent auxiliary electric machinery and which stop upon power loss on the main switchboard, provision is to be made for remote or automatic programmed starting of the machinery when the power supply is restored;

.7 if the remote control system fails, the preset mode of operation of the propulsion machinery and propellers is to be maintained until change-over to local control or until the plant is brought to fail-safe condition (stoppage of propellers), if the maintenance of the preset mode is impracticable or unreasonable;

.8 remote control system is to ensure emergency manoeuvring whereby a change in speed of a self-propelled MODU and in direction of its movement for the opposite is to be achieved within the shortest time possible. Besides, power limitations, if set below the nominal value, are to be automatically removed.

4.2.3 Where there are several control locations of the propulsion plant, the one in the main machinery control room is to predominate over the one on the navigating bridge (main control station).

The same is true in respect of the control location in the main machinery space as compared to that in the main machinery control room.

The transfer of control to a predominant control location and back is to be possible from a predominant location only, in any moment and irrespective of the position of the remote controls (the transfer of control is to be effected by the personnel, wherever possible, without substantial alteration of the rotational speed and thrust of the propulsion plant).

The transfer of control is to be accompanied with visual and audible signals released at all the control locations. At the locations, provision is to be made for light signals (indicators) showing from which location control is effected.

The possibility of simultaneous control from different locations is to be ruled out. Where several controls are provided at the locations (e.g. at bridge wings and in the centre), they are to be either mechanically or electrically synchronized.

At all the control locations including the disconnected ones, provision is to be made for non-disconnectable indication of commands transmitted by engine telegraph.

4.2.4 The propulsion machinery emergency stop device, if electrically operated, is to be independent of remote control system, alarm and safety systems, and of the unit's mains.

4.2.5 With regard to the safety system, provision is to be made for an automatic power reduction in case of faults not involving direct damage to the propulsion plant.

4.2.6 In case of main internal combustion machinery plants, to be automatically kept within the prescribed limits is the temperature of the working liquids as listed below:

cylinder cooling water;

piston cooling water (medium);

fuel valve coolant;

lubricating oil;

fuel oil if heavy oil is used and no viscosity control is provided.

As far as propulsion plants having driving machinery of other types are concerned, the automatic regulation of working liquid temperature is to be agreed with the Register.

4.2.7 The number of successful automatic starts made by the remote control system from a non-replenishable power source for starting is not to be less than required in 3.2.4, Part VIII "Systems and Piping" of MODU/FOP Rules, and the normal functioning of the remote control system is not to be limited in case of the starting air pressure drop or the capacity of starting accumulator batteries decrease lower than the limits of alarm actuation.

The number of ineffective attempts of automatic starting is to be limited by two or three attempts so that after the last ineffective attempt made by the remote control system, the starting air quantity or accumulator battery capacity is sufficient to effect manually a half number of starting attempts as required in 3.2.4, Part VIII "Systems and Piping" or 13.7.2, Part XI "Electrical Equipment" of MODU/FOP Rules.

4.2.8 With regard to geared diesel plants (two diesels or more), provision is to be made that, with one diesel engine shut down, the others go on running without being overloaded.

4.2.9 A permanent indication is to be provided on the control desks to show execution by the control system of the commands set by the operator. Controlled parameters of automated propulsion plant, measuring points, limiting values of parameters and types of automatic protection and indication are to be found in Table 4.2.9.

Table 4.2.9

No.	Controlled parameter	Measuring point	Alarms for limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
1	**Internal combustion engines**					
1.1	Lubricating oil system					
1.1.1	Lubricating oil pressure	Main and thrust bearings	Min.	Shut-down	Continuous	Automatic start of standby pump
1.1.2	Lubricating oil pressure drop	Filter	Max.		On call	
1.1.3	Lubricating oil temperature	At inlet	Max.		On call	
1.1.4	Lubricating oil flow from lubricators	At outlet	Min.	Slow-down		
1.1.5	Oil mist concentration or bearing temperature	In crankcase	Max.	Shut-down		For engines having power of 2250 kW or with cylinder bore of 300 mm and over
1.1.6	Lubricating oil level	In oil drain tank	Min.			
1.2	Turbo-blower lubrication system					
1.2.1	Turbo-blower oil pressure	At inlet	Min.			
1.2.2	Turbo-blower bearing oil temperature	At outlet	Max.			
1.2.3	Oil level in turbo-blower lubrication system	In tank	Min.			
1.3	Sea water cooling system					
1.3.1	Sea water pressure	At inlet	Min.	Automatic start of standby pump	Continuous	
1.4	Fresh water cooling system					
1.4.1	Pressure or flow in cylinder cooling system	At inlet	Min.	Automatic start of standby pump	Continuous	

Table 4.2.9 — continued

No.	Controlled parameter	Measuring point	Alarms for limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
1.4.2	Cooling water temperature	At outlet	Max.		On call	
1.4.3	Cooling water level	Expansion tank	Min.			
1.5	Scavenging air system					
1.5.1	Scavenging air temperature		Max.		Continuous	
1.6	Fuel oil system					
1.6.1	Fuel oil pressure downstream of filter	At inlet	Min.	Automatic start of standby pump	Continuous	
1.6.2	Fuel oil viscosity downstream of filter or fuel oil temperature	At inlet of fuel injection pump.	Max. Min.			
1.6.3	Fuel oil level	Daily service tank	Min.			
1.6.4	Fuel oil leakage from high-pressure piping	Down stream of fuel injection pump	Presence of fuel oil			
1.6.5	Gas concentration	Machinery spaces	Max.[5]	Automatic shutdown of engine. Closing of the main valve for gas fuel		Required where installations with dual-fuel (gas-liquid fuel) engines are used
1.6.6	Gas concentration	Piston underside spaces	Max.	Activation of the interlocked valves[4]		For cross-head dual-fuel (gas-liquid fuel) engines
1.6.7	Gas concentration	Crankcase	Max.	Activation of the interlocked valves[4]		For trunk-piston dual-fuel (gas-liquid fuel) engines
1.6.8	Inert gas pressure	Between the concentric pipes of piping	Max.	Activation of the interlocked valves[4] Closing of the main valve for gas fuel		Required where installations with dual-fuel (gas-liquid fuel) engines are used provided there is the piping system with double walls; the space between the walls shall be filled with inert gas under pressure exceeding gas fuel pressure
1.6.9	Gas concentration	Ventilation duct or vent pipe	Max.	Activation of the interlocked valves[4] Closing of the main valve for gas fuel		Required where installations with dual-fuel (gas-liquid fuel) engines are used provided the piping system is led in ducts and pipes with mechanical ventilation
1.6.10	Ignition failure	At each cylinder	Ignition of fuel failure	Activation of the interlocked valves[4]		For dual-fuel (gas-liquid fuel) engines. Fuel ignition control may be substituted for pressure control at each cylinder
1.6.11	Gas fuel injectors failure and auxiliary liquid fuel injectors failure	Each fuel injector	Failure	Activation of the interlocked valves[4]		For dual-fuel (gas-liquid fuel) engines
1.7	Exhaust gas system					
1.7.1	Exhaust gas temperature	At outlet of each cylinder	Max.	Slow-down	Continuous	
1.7.2	Deviation from average value of exhaust gas temperature		Max.			When power is over 500 kW/cyl.
1.8	Starting and control air system					
1.8.1	Starting air pressure	At inlet of master starting valve	Min.	At outlet	Continuous	
1.8.2	Control air pressure		Min.		Continuous	
1.9	Engine load		Max.	Slow-down		

Table 4.2.9 — continued

No.	Controlled parameter	Measuring point	Alarms for limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
1.10	Engine speed					
1.11	Engine overspeed (racing)		Max.	Shut-down		
1.12	Power supply to control, safety and alarm systems		Loss of power			
2	**Steam turbines**					
2.1	Lubricating oil pressure	At inlet	Min.	Shut-down of turbine	Continuous	
2.2	Lubricating oil pressure drop	Filter	Min.			
2.3	Lubricating oil temperature	At bearing outlet	Max.		Continuous	
2.4	Lubricating oil level	Gravity tank	Min.	Shut-down of turbine	On call	
2.5	Steam temperature	Before manoeuvring valves	Max/Min		On call	
2.6	Steam pressure	Condenser	Max.	Shut-down of turbine	Continuous	
2.7	Steam pressure	Before manoeuvring valves	Max.		Continuous	
2.8	Pressure	Deaerator	Max/Min.		On call	
2.9	Water level	Deaerator	Max/Min.		On call	
2.10	Water level	Condenser	Max/Min	Shut-down of turbine	On call	
2.11	Water pressure	After condensate pump	Min.		On call	
2.12	Condensate salinity		Max.			
2.13	Turbine vibrations		Max.	Shut-down of turbine		
2.14	Axial displacement of rotor		Max.	Shut-down of turbine		
2.15	Steam pressure	End glands	Max.		Continuous	
2.16	Sea water pressure	At outlet of circulating pumpm	Min.		Continuous	
3	**Gas turbine engines (main and auxiliary ones)**					
3.1	Lubricating oil pressure	At gas turbine engine inlet	Min.	Shut-down of gas turbine engine	Continuous	
3.2	Lubricating oil temperature	At inlet	Max.		On call	
3.3	Bearing temperature	Each bearing	Max.		On call	
3.4	Gas temperature	At gas turbine engine outlet	Max.	Shut-down of gas turbine engine	Continuous	For auxiliary gas turbine engines at outlet
3.5	Flame-out or ignition system failure or stratification of temperatures over flame tubes	At gas turbine engine outlet	Max.	Shut-down of gas turbine engine	On call	
3.6	Automatic start system		Ex-post signals			
3.7	Fuel oil pressure	Before burners	Min.		Continuous	When gas is used Shut-down of gas turbine engine
3.8	Fuel oil pressure	At gas turbine engine inlet	Min.		Continuous	When gas is used Shut-down of gas turbine engine
3.9	Fuel oil temperature	Before burners	Max., min.		On call	When high-viscosity fuels are used
3.10	Pressure drop	At air-intake filter	Max.		On call	
3.11	Gas turbine engine vibration	At each support	Max.	Shut-down of gas turbine engine	On call	For auxiliary gas turbine engines alarm only

Table 4.2.9 — continued

No.	Controlled parameter	Measuring point	Alarms for limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
3.12	Axial displacement of rotor		Max.	Shut-down of gas turbine engine		For auxiliary gas turbine engines alarm only
3.13	Turbine speed	At each rotor	Max.	Shut-down of gas turbine engine	Continuous	Shutdown resulted from power turbine speed
3.14	Oil level	In lubricating oil tank	Min.		On call	
3.15	Automatic shut-down of gas turbine engine		Ex-post signal			
3.16	Gas pollution of engine room	Engine room	Max.	Shut-down of gas turbine engine	Continuous	When gas is used
3.17	Temperature under sheath	Under sheath	Max.	Continuous		
3.18	Gas temperature after gas turbine engine	After gas turbine engine	Max.		On call	
3.19	Power supply to control, safety and alarm systems				Continuous	
4	**Shafting**					
4.1	Temperature of thrust bearing (or lubricating oil at outlet)		Max.	Slow-down		
4.2	Temperature of shaft bearings (or lubricating oil at outlet)		Max.			
4.3	Temperature of sterntube bearing (or presence of lubricating oil flow)		Max.			
4.4	Lubricating oil level in sterntube lubricating tank or sterntube coolant flow		Min.			
5	**Controllable pitch propellers**					
5.1	Hydraulic oil pressure	After filter	Min.			
5.2	Hydraulic oil level	Header tank	Min.			
5.3	Electrical power supply	To power and control circuits	Loss			
6	**Reduction gears and couplings/clutches**					
6.1	Lubricating oil pressure	At inlet	Min.	Shut-down	Continuous	Where a coupling/clutch is fitted, disengagement of same may be effected instead of engine shut-down
6.2	Lubricating oil temperature	At outlet	Max.	Slow-down		
6.3	Bearing temperature		Max.			For engines having power of 2250 kW and over
6.4	Hydraulic oil pressure	At inlet of coupling/clutch	Min.		Continuous	
Note. On agreement with the Register, special visual and audible signals may be provided instead of slowdown where internal combustion engines are concerned.						

4.3 AUTOMATED BOILER PLANTS

4.3.1 The requirements of this Chapter cover boiler plants with oil-burning installations.

4.3.2 Steam boilers are to be fitted up with automatic water level regulators and combustion controls to maintain automatically the steam pressure within pre-set range.

4.3.3 Automated boilers are to have at least two water level transducers independent of each other and connected to output devices located at different heights, one of which is to be used solely for low water level protection.

The second transducer may also be used for shutdown in case of low water levels, or for alarm and for feed water regulating system.

4.3.4 Provision is to be made for a remote shutdown of automated boiler plants from the main machinery control room or from the control station where continuous watch is kept.

4.3.5 Automated oil-burning installations are to be fitted with interlocking devices to permit fuel oil being fed into the boiler furnace only when the requirements listed below are complied with:

.1 fuel oil viscosity (temperature) is such that adequate atomization is assured;

.2 boiler furnace is so pre-purged that normal ignition of flame-jet and sufficient air changes are ensured therein;

.3 fuel oil supply to burners is set to minimum permissible quantity to ensure steady combustion.

4.3.6 As far as the automated oil-burning installations are concerned, the oil supply to the burners is to be cut off automatically under the following circumstances:

.1 absence of flame for not more than 5 s from the moment the oil supply begins;

.2 fuel oil viscosity (temperature) being insufficient for atomization;

.3 degradation of parameters of vapour or air intended for fuel oil atomization;

.4 fuel oil supply decreases below the level at which the flame-jet burns steadily.

4.3.7 Starting of boiler plants from cold condition and after being shut down by protection system is to be possible from the local control station only.

4.3.8 If the ignition of fuel oil fails, re-starting of the burner is to be possible from the local control station only after the boiler furnace has been appropriately pre-purged.

4.3.9 Controlled parameters of automated boiler plants, measuring points, limiting parameter values and types of automatic protection and indication are to be found in Table 4.3.9.

4.4 AUTOMATED ELECTRIC POWER PLANTS

4.4.1 The electric power plants on MODU or FOP are to ensure electric power supply for the consumers in conformity with the following requirements:

4.4.1.1 On MODU or FOPs where the main industrial loads are taken up by one generator, control devices are to be provided to ensure:

.1 automatic starting of standby generator, automatic synchronization, taking over and sharing of load in case:

maximum permissible load is reached by the generator during operation (85 per cent, for instance), or

there is malfunction of the operating unit which enables an automatic synchronization of generators to be carried out and the load to be transferred to the standby generator without any loss of voltage on the main switchboard busbars;

.2 automatic starting of standby generator and its connection to the main switchboard busbars within 30 s if the running generator fails and the main switchboard is in "black-out" position.

Table 4.3.9

No.	Controlled parameter	Alarms for limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
1	**Main boilers**				
1.1	Steam pressure in boiler drum	Max.	Shutdown	Continuous	
1.2	Steam temperature after superheater	Max.		On call	
1.3	Steam temperature after steam cooler	Max.		On call	
1.4	Water level in boiler drum	Min.	Shutdown	Continuous	
1.5	Feed water pressure after pump	Min.	Shutdown	Continuous	
1.6	Fuel oil pressure before burner	Min.	Shutdown	On call	
1.7	Pressure of steam or air used for atomization	Min.	Shutdown		
1.8	Fuel oil viscosity (temperature) before burner	Min.			
1.9	Air pressure before furnace	Min.	Shutdown		
1.10	Feed water salinity	Max.			
1.11	Flame	Flame failure	Shutdown		
1.12	Fuel oil level in daily service tank	Min.			
1.13	Fuel oil temperature in daily service tank	Min.			
1.14	Electric power supply to boiler controls	Power loss	Shutdown		
2	**Thermal oil boilers**				
2.1	Thermal oil pressure at boiler outlet	Max.	Shutdown		
2.2	Thermal oil temperature at boiler outlet	Max.	Shutdown		
2.3	Thermal oil flow at boiler outlet	Min.	Shutdown	Continuous	
2.4	Thermal oil level in expansion tank	Min.	Shutdown	Continuous	

Note. In the main machinery control room, common alarms may be used provided identification is possible at the local control station.

When the voltage on the switchboard busbars is restored, essential auxiliary machinery are to be re-started automatically as specified in 4.4.2.

4.4.1.2 On MODU or FOP, where electrical power is normally supplied from two or more generators operating in parallel, means are to be provided (automatic disconnection of less important services, for instance) to prevent overload of the remaining generators and deenergizing of the main switchboard busbars in case one of the generators fails in order to ensure safe functioning of the unit.

4.4.2 When the voltage on the main switchboard busbars is restored after black-out, the start of key machinery essential for normal functioning of the MODU is to be effected automatically in accordance with a specified program and in such a way that the electric power plant is not overloaded.

4.4.3 When, at load reduction on the electric power plant, the generators are to be disconnected automatically, provision is to be made to the effect this would not also happen at momentary load variations.

4.4.4 The drives of generators started automatically are to be ready to start immediately. A visual signal is to be provided to indicate readiness.

When the drives are not ready to be started immediately, an indicator is to be provided to warn that automatic starting is impossible.

4.4.5 When the standby generators are to start automatically if the running ones are overloaded, provision is to be made for the following:

.1 automatic synchronization and connection;

.2 automatic load sharing;

.3 preliminary determination of sequence in which the generators are to be started and connected to the collecting busbars of the main switchboard.

4.4.6 Where a water pump or independently driven fan is used to cool the generators, provision is to be made for an alarm system to indicate when the cooling system fails, as well as for an automatic protection of the generators against overheating by way of disconnection of non-essential consumers.

4.4.7 Automated electric power plants are to ensure automatic and remote connection of electric generators including automatic synchronization, taking over and sharing of load.

4.4.8 Controlled parameters of automated electric power plants (except emergency ones), limiting values of parameters and types of automatic protection and parameter indication are to be found in Table 4.4.8.

4.5 AUTOMATED COMPRESSOR PLANTS

4.5.1 Automated compressor plants are to be capable to operate in manual remote and automatic mode. In automatic mode, the rated compressed air pressure is to be maintained in air receivers in such a way that:

when the air pressure drops to the pre-set value, for example to 90 per cent, the pre-selected compressor

Table 4.4.8

No.	Controlled parameter	Measuring point	Alarms for limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
1	**Ship mains**					
1.1	Voltage on main switchboard		Min.	tripping of generator's circuit-breaker	Continuous	Where the main switch-board is installed in main machinery control room no additional indication is required
1.2	Current frequency on main switchboard		Min.		Continuous	
1.3	Insulation resistance on main switchboard		Min.		Continuous	
2	Generators					
2.1	Load (current) on main switchboard		Max Max Max.	a) alarm signal b) disconnection of nonessential consumers c) disconnection of generator		Effected by the protection system of generators
2.2	Reverse power (current) on main switchboard		Max.	tripping of generator's circuit-breaker		
2.3	Generator winding temperature		Max.			When the power is 5000 Kw and over

Table 4.4.8 — continued

No.	Controlled parameter	Measuring point	Alarms for limited values of parameters	Automatic protection	Indication in main machinery control room	Comments
3	**Internal combustion engines for driving generators**					
3.1	Lubricating oil pressure	At engine inlet	Min.	Engine shutdown	Continuous	
3.2	Lubricating oil temperature	At engine inlet	Max.		On call	
3.3	Oil mist concentration or bearing temperature		Max.	Engine shutdown		Automatic stop of diesel generators at such parameter may be permissible where high certainty of signal is provided
3.4	Cooling water pressure or flow	At engine inlet	Min.			
3.5	Cooling water temperature	At engine outlet	Max.		On call	
3.6	Sea water pressure or flow	At engine inlet	Min.			
3.7	Fuel oil pressure	At engine inlet	Min.			
3.8	Fuel oil viscosity (temperature)	At engine inlet	Max.(Min.)			
3.9	Fuel oil leakage from HP piping	After fuel oil injection pump	Presence of fuel oil			
3.10	Exhaust gas temperature	At engine outlet	Max.		On call	
3.11	Fuel oil level in daily service tank		Min.			
3.12	Cooling water level in expansion tank		Min.			
3.13	Starting air pressure before starting valve		Min.			
3.14	Speed (racing)		Max.	Engine shutdown		
4	**Steam turbines for driving generators**					
4.1	Lubricating oil pressure	At inlet	Min.	Turbine shutdown	Continuous	
4.2	Lubricating oil temperature	At bearings	Max.		On call	
4.3	Steam pressure before turbine		Min.		Continuous	
4.4	Steam pressure in condenser		Max.	Turbine shutdown	On call	
4.5	Water level in condenser		Max.			

starts automatically and stops automatically as soon as the air pressure equal to the rated one is reached;

in case of intensive consumption of air and further reduction of its pressure, for example to 80 per cent, the second compressor being in the automatic mode starts and both compressors continue to operate until the rated pressure is reached.

Other methods of operation of automated compressors are subject to special consideration by the Register.

4.5.2 For compressors, provision is to be made for regulating the starting pressure.

4.5.3 Compressed air systems are to be fitted up with automatic drainage devices.

4.5.4 Automated compressor plants are to keep up the starting and operational air vessel pressure at a level which would suffice at least to comply with the requirements stated in Part VIII "Systems and Piping" of MODU/FOP Rules.

4.5.5 Controlled parameters of automated compressor plants, limiting values of parameters and types of automatic protection and indication are to be found in Table 4.5.5.

Table 4.5.5

No	Controlled parameter	Measuring point	Alarms for limited values of parameters[1]	Automatic protection	Indication in machinery control room	Comments
1	Lubricating oil pressure	At compressor inlet	Min.	Compressor shutdown	Continuous	
2	Coolant flow		Min.	Compressor shutdown		
3	Air temperature	At compressor inlet	Max.			
4	Starting air pressure		Min.		Continuous	
5	Control air pressure	At compressor outlet	Min.		Continuous	

[1]Common alarms are permitted in the main machinery control room on condition that provision is made for identification at the local control station.

4.6 AUTOMATED PUMPING PLANTS

4.6.1 Automated el-driven pump control system is to ensure automatic starting of standby pumps and change over as necessary in systems in case of pump failure or upon reaching the highest permissible deviations of parameters in essential circulation systems. The faulty pump is to be stopped and an alarm given only after the standby pump has been started.

4.6.2 The electric control diagrams of el-driven pumps having equal output is to make it possible to use each of them as the main pump.

4.6.3 It is advisable that the fire pumps be automatically started upon operation of the following signals:

from the fire detection and alarm system, in case of a true signal "Fire";

in case of pressure drop in the fire main which is kept permanently under pressure.

4.6.4 Remote starting of the fire pumps is to be effected:

from the main machinery control room,

from the standby control station,

from the emergency control station.

4.7 AUTOMATED BILGE PLANTS

4.7.1 Depending on the water level in the wells, the automated bilge plants are to put automatically relevant bilge pumps in operation. A signal for pump operation is to be provided.

4.7.2 If, after the bilge pumps have been started, the water goes on rising or does not fall within a specified period of time, an alarm is to be activated.

4.7.3 A separate sensor is to be provided to signal the highest possible level, which would be independent of the sensors fitted to control the bilge pumps.

4.7.4 The arrangement of sensors is to make it possible to determine the water level under normal and emergency conditions of heel and trim of the unit.

4.7.5 Controlled parameters of automated bilge plants, limiting values of parameters, types of protection and parameter indication are to be found in Table 4.7.5.

Table 4.7.5

Controlled parameters	Measuring point	Alarms for limiting values of parameters	Automatic protection	Indication of parameters in main machinery control room	Comments
Water level	Bilge wells	Max.			
Water level in emergency	Bilge wells, shaft passages	Max.			

4.8 AUTOMATED REFRIGERATING PLANTS

4.8.1 In accordance with 1.1, Part XII "Refrigerating Plants" of the Rules for the Classification and Construction of Sea-Going Ships, automated refrigerating plants are to comply with the requirements of 7.2.

4.8.2 Provision is to be made for indication of the automated refrigerating plant operation and for a common alarm of its malfunction and failure.

4.8.3 Controlled parameters of automated refrigerating plants, measuring points, limiting values of parameters, types of protection and parameter indication are to be found in Table 4.8.3.

Table 4.8.3

Controlled parameters	Measuring point	Alarms for limiting values of parameters	Automatic protection	Indication of parameters in main machinery control room	Comments
Condition of refrigerating plant	Compressor	Malfunction Failure	Compressor shutdown	Common alarm	

5 COMPUTERS AND COMPUTER BASED AUTOMATION SYSTEMS

5.1 APPLICATION

5.1.1 The present requirements apply to computers and computer based systems serving the following essential functions:

control of propulsion plant of MODU;

control of steering system (autopilot);

automated control of electric power plant;

fire detection and alarm systems and alarm systems to indicate explosive concentrations of gas-air mixtures;

general alarm systems;

warning alarm systems of machinery installation or integrated control and monitoring systems;

systems used to ensure stability of MODU and to carry out procedures of submersion and emersion of the submersible and semi-submersible MODU;

anchoring and dynamic positioning systems of MODU;

other similar automation systems.

5.1.2 The present requirements apply also to computer based systems of non-essential services, for example, domestic water boilers, where loss of control can result in serious damage to the MODU or FOP, to machinery or serious injury to personnel.

5.2 DEFINITIONS AND EXPLANATIONS

5.2.1 Computer is a programmable electronic device for mathematical processing and storing data in the digital form, making calculations and/or producing the logic for control functions.

Computer based system is a system of one or more computers, associated software, peripherals and interfaces which implement links with set-point devices, sensors and actuators.

Integrated system is a combination of computer or computer based systems which are interconnected by a data communication link in order to allow centralised access to information with the aim of implementing control and monitoring functions of machinery and equipment.

Interface is a transfer point at which information in digital form is exchanged.

Node is a point of interconnection to a data communication link.

Software are programs, data and documentation associated with the operation of a computer based system.

5.3 DESIGN OF COMPUTER BASED SYSTEMS USED IN CONTROL AND MONITORING

5.3.1 The computers and computer based systems are to fulfill 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.

5.3.2 If the process time for functions of the computer based control system is shorter than the reaction time of the operator and therefore damage cannot be prevented by manual intervention, means of automatic intervention are to be provided.

5.3.3 A computer based system is to have sufficient capabilities (hardware and software ones) to:

perform necessary autonomous operations;

accept operator (user) commands;

inform the operator (user) correctly and in proper time;

under all operating conditions including emergency.

5.3.4 System capability is to provide adequate response time 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.

5.3.5 Computer based systems are to be designed in such a way that they can be used without special previous knowledge. To handle particularly complicated systems the manufacturer is to provide appropriate technical assistance for the user and training of the personnel.

5.3.6 Computer based systems are to be protected against unintentional or unauthorized modification of programs and data.

5.4 HARDWARE

5.4.1 Hardware of computers and peripherals is to be suitably designed to withstand supply voltage variations and transients, ambient temperature changes, humidity, vibration, electromagnetic interference, corrosion, etc, normally encountered on board, as specified in 2.1.

5.4.2 The design of the hardware is to ensure easy access to interchangeable parts for repairs and maintenance.

5.4.3 Each replaceable part (printed circuit board, unit) is to be simple to replace and is to be constructed for easy and safe handling. All replaceable parts are to be so arranged that it is not possible to connect them incorrectly or to use incorrect replacements. Where this is not practicable, the replaceable parts are to be clearly marked.

5.4.4 The computer based systems are to be, wherever possible, so constructed that no fans for forced cooling of processors and thermally stressed elements need to be provided. Where forced ventilation is used, an alarm is to be provided to operate when the temperature exceeds the limiting value permissible in case of the fan failure.

5.5 SOFTWARE

5.5.1 Systematic monitoring procedures are to be followed during all phases of the software life cycle (development, installation, debugging, normal operation and subsequent modification).

5.5.2 System tests are to be specified, performed and documented. These tests are to include all software functions and important logical and temporary combinations of functions, performance, dependability and usability requirements under all modes of operation including emergency conditions and behaviour under failure conditions.

5.5.3 Any modifications of program contents and data are to be made by competent specialists and documented.

5.6 SYSTEM CONFIGURATION

5.6.1 General.

5.6.1.1 The hardware and software are to be of modular, hierarchical design in order to maximise the fault tolerance of the system.

5.6.1.2 The selection of the computer equipment is to be made to provide completeness and sufficiency of the functions to be implemented, consistent with safe operation of the system under control.

5.6.2 Self-test.

5.6.2.1 Computer based systems are to have a built-in self-test capability to monitor for correct operation and an alarm is to be released at the desks of the control and monitoring stations to indicate an abnormal condition

5.6.3 Power supply.

5.6.3.1 All sources of power supply are to be monitored for failure and are to give an alarm in the event of abnormal condition.

5.6.3.2 Programs and data held in the system are to be protected against damage and corruption by loss of power.

5.6.3.3 Redundant systems are to be selectively fed and separately protected against short-circuits and overloads.

5.6.4 Installation.

Equipment and its associated cabling are to be installed in such a way as to minimise electromagnetic interference between the equipment concerned and other radiating equipment on board.

5.6.5 Cables.

Cables used for data communication are to be of adequate mechanical strength, suitably supported and also protected from mechanical damage.

5.6.6 Data communication.

5.6.6.1 The data communication link is to be continuously self-checking, for detecting failures on the link itself and data communication failure on nodes and is to give an alarm in the event of abnormal condition.

5.6.6.2 When the same data communication link is used for two or more essential functions, this link is to be redundant. Redundant data communication links are to be routed with as much separation as practical.

5.6.6.3 Switching between redundant links is not to disturb data communication or continuous operation of functions.

5.6.6.4 To ensure that data can be exchanged between various systems, standardized interfaces are to be used.

5.6.7 Failure to safety.

5.6.7.1 In the event of failure of a computer based system, systems under control are to automatically revert to the least hazardous condition.

5.6.7.2 The failure, malfunction and subsequent restarting of computer based systems is not to cause processes to enter undefined or critical states.

5.6.7.3 Control, alarm and safety functions are to be arranged such that a single failure will not affect more than one of these functions.

5.6.8 Integration of systems.

5.6.8.1 Operation with an integrated system is to be at least as effective as it would be with individual, stand-alone equipment. Where multifunction displays and controls are used they are to be duplicated and interchangeable.

5.6.8.2 Failure of one part (individual module, equipment or subsystem) of the integrated system is not to affect the functionality of other parts, except for those functions directly dependent upon information from the defective part.

5.6.8.3 Complete failure in connectivity between parts of the integrated system is not to affect their independent functionality.

5.6.8.4 Alternative or standby means of operation, independent of the integration, are to be available for all the particularly essential control and monitoring functions.

5.6.8.5 When systems under control (e.g. power units) are required to be duplicated and located in separate compartments this is to be also applied to computer based systems used for control and monitoring.

5.7 USER INTERFACE

5.7.1 General.

5.7.1.1 Computer based systems are to be designed for ease of handling and user-friendliness and are to follow ergonomic principles.

5.7.1.2 The operational status of a computer based system (on, off, non-failed, failed, etc) is to be easily recognizable at the control and monitoring stations.

5.7.1.3 A user guide is to be provided. The user guide is to describe at least:

function keys;

menu displays;

computer-guided dialogue steps, etc.

5.7.1.4 An alarm is to be displayed at relevant visual display units or operator stations for failure or shutdown of a subsystem.

5.7.2 Input devices.

5.7.2.1 Input devices are to have clearly definable functions, be reliable in use and operate safely under all conditions. The acknowledgement of the instruction given is to be easily recognizable.

5.7.2.2 Dedicated function keys or special controls are to be provided for frequently recurring commands and for commands which must be available for rapid execution. If multiple functions are assigned to keys, it is to be possible to recognize which of the assigned functions is active.

5.7.2.3 Control panels on the navigating bridge are to be provided with separate lighting. Visual display units are to be controllable dimmer system provided.

5.7.2.4 Where equipment operations or functions may be changed via keyboards access to such operations is to be provided for authorized personnel only.

5.7.2.5 If operation of a key is able to cause dangerous operating conditions for the equipment (systems under control), at least the following measures are to be taken to prevent the instruction in question from being executed by unauthorized personnel:

use of a special key lock, or

use of two or more keys, or

use of special passwords for access.

5.7.2.6 Conflicting control interventions are to be prevented by means of interlocks or warnings. The active control status is to be displayed on a visual display by text or symbols recognizable to the operator.

5.7.3 Output devices.

5.7.3.1 The size, colour and density of text and graphic information displayed on a visual display unit are to be such that it may be easily read from the normal operator position under all operational lighting conditions. The brightness and contrast are to be capable of being adjusted to the prevailing ambient conditions in order to enable the information to be normally recognized.

5.7.3.2 Information is to be displayed in logical priority, that is, the most important information is to be focussed in those portions of the screen where it is most clearly visible to the operator.

5.7.3.3 If alarm messages are displayed on colour monitors, they are to be distinguished in red and the information is to be clear and intelligible even in the event of failure of a primary colour.

5.7.4 Graphical user interface.

5.7.4.1 Information is to be presented clearly and intelligibly according to its functional significance and association. Screen contents are to be logically structured and their representation is to be restricted to the data which are directly relevant to the operator who is given appropriate authority.

5.7.4.2 When using general purpose graphical user interface, only the functions necessary for the respective process are to be available.

5.7.4.3 Alarms are to be visually and audibly presented with priority over other displayed information in every operating mode of the system; they are to be clearly distinguishable from other information.

5.7.4.4 All display and control functions in control stations operated by the same operators are to adopt a consistent user interface. Particular attention is to be paid to mandatory identity of:

symbols;

colours;

controls;

information priorities;

layout.

5.8 TRAINING

5.8.1 For complicated computer based systems used in control and monitoring, training is to be provided at a level required to effectively operate and maintain the system and is to cover normal, abnormal and emergency conditions. The user interface for training is to correspond with the real system.

5.8.2 Documentation is to be provided to support the training and is to be available for repeated use on board the MODU.

5.8.3 Where a training mode is incorporated in a computer based system it is to be clearly indicated when the training mode is active.

5.8.4 Whilst in the training mode the operation of the system is not to be impaired, and neither are any system alarms or indications to be inhibited.

5.9 TESTING

5.9.1 The computer based systems are to be designed, manufactured and tested in accordance with the requirements of this Section and other requirements of the Rules, which is to be confirmed by an appropriate Certificate of the Register. In case of any integrated systems the evidence that the computer based system conforms fully to the functional requirements is to be indicated in the technical documentation and Certificate of the integrated system.

5.9.2 In addition to the requirements of this Section manufacturers are to ensure by means of quality control system surveyed by the Register or another classification society that their products meet their quality specifications..

5.9.3 Tests and inspections of a computer based system are to be carried out with the aim of establishing the correct operation and the quality of a product.

5.9.4 Modifications of program contents and data, as well as change of version, are to be checked and tested before the system is put into operation.

6 UNITS HAVING AN AUTOMATION MARK IN THEIR CLASS NOTATION

6.1 GENERAL

6.1.1 The requirements of the present Section apply to MODU/FOP which in compliance with 2.4.1 of Part I “Classification” of MODU/FOP Rules are assigned one of the automation marks (**A1**, **A2**, **A1K**, **A2K**, **A1И**, **A2И**) in their class notation.

Such MODU/FOP are to be equipped with automation systems of their electric power plants and/or machinery (propulsion) plants to the extent sufficient to ensure their safety under all sailing (operational) conditions without permanent attendance of machinery spaces.

The requirements of the present Section may also apply to MODU/FOP without automatic mark in their class notation, but which are provided with a main machinery control room, remote automated control systems of propulsion plants, as well as an automated electrical power plant and a centralized alarm system.

6.1.2 The automation systems and devices installed are to comply with the requirements of relevant Sections of the present Part, as well as with the applicable requirements of other Parts of MODU/FOP Rules.

6.1.3 To be automated are at least the following plants:

propulsion plant, if provided, complying with the requirements of 4.2;

electric power plant, complying with the requirements of 4.4;

boiler plant complying with the requirements of 4.3;

compressor plant complying with the requirements of 4.5;

pumping plants complying with the requirements of 4.6, 4.7;

other essential plants used to support the main operating practices on the MODU or FOP.

6.1.4 Provision is to be made for an alarm system to cover all the parameters and working conditions controlled, as mentioned in Section 4 and in this Section.

6.1.5 All equipment installed in a machinery space is to be adapted to unattended service. On agreement with the Register, some operations (replenishment of tanks, cleaning of filters, etc) may be effected from local control stations, if carried out at certain intervals (not more than once every 12 h) and adequately serviced.

6.1.6 Provisions concerning fire protection are to be found in Part VI "Fire Protection" of MODU/FOP Rules.

6.2 DEVICES AT THE MAIN CONTROL STATION

6.2.1 The main control station is to be equipped with controls of the propulsion plant, if provided, as well as with a common alarm system of the machinery (electric power) plant providing the following separate signals:

"Water in machinery space";

"Fire in machinery space";

"Alarm system failure".

6.2.2 Provision is to be made for an alarm system to pre-warn (5 to 10 s in advance) of the development of a fault, which brings about shut-down of the propulsion plant.

6.2.3 A "Dead man" alarm system is to be provided.

6.2.4 Provision is to be made for arrangements for emergency shut-down of machinery and devices as required by 9.6, Part X "Electrical Equipment" of MODU/FOP Rules.

6.3 DEVICES IN MACHINERY SPACES

6.3.1 Provision is to be made for an enclosed main machinery control room fitted up with the following:

controls and devices cited in 3.2, of Part VII "Machinery Installations" of MODU/FOP Rules,

centralized alarm, indication and logging system, as well as signal devices to indicate operation of the protection system of the machinery units;

visual signals (indicators) to indicate the operation modes of machinery and plants;

disconnecting devices of the burning installations of boilers, fans of machinery spaces, fuel and lubricating oil transfer pumps;

separate signals "Water in machinery space" and "Fire in machinery space";

as well as the following additional devices:

.1 remote controls of auxiliaries serving the propulsion machinery if the latter are not automated;

.2 signalling devices to indicate which machinery and plants were in operation when the main switchboard became deenergized that are to be started remotely as the voltage is restored;

.3 indicators and alarms of the automated refrigerating plant;

.4 indicators and alarms of the automated industrial machinery and devices.

6.3.2 A personnel call device is to be fitted connected to particular sections of machinery spaces.

6.3.3 Safety signboards bearing the inscription "Attention! Machinery are started automatically" are to fitted at the entrances to periodically unattended machinery spaces.

6.4 DEVICES IN ENGINEERS' ACCOMMODATION

6.4.1 In engineers' accommodation and public spaces common alarm devices (units) are to be fitted to warn of the malfunctions of machinery and plants in machinery spaces and also separate signals: "Water in the engine room" and "Fire in the engine room". The acknowledgement of each signal of these devices is to be indicated at the main control station by muting the audible signal only.

6.4.2 Devices mentioned in 6.4.1 may be switched to inoperable condition, but at least one of the devices (for the personnel on duty) is to remain in "on" condition.

6.4.3 The common alarm devices are to be also fitted in other spaces where the personnel attending the machinery installation may be staying.

6.5 ELECTRIC POWER PLANT

6.5.1 Where no provision is made for an automated electric power plant in conformity with 4.4, the following is to be available:

.1 inoperative driving machinery of generators is to be kept ready to immediate start;

.2 driving machinery of generators is to be remotely started and shut down from the engine control room;

.3 remote synchronizing, connection and load sharing from the main machinery control room. Synchronizing, connection and load sharing may be effected from the main switchboard if installed in the engine control room.

6.5.2 Where particular functions of the electric power plant are automized, the relevant requirements of 4.4 are to be complied with.

6.6 PROPULSION PLANTS

6.6.1 The remote control systems of the propulsion plants of self-propelled mobile offshore drilling units (MODU) are to ensure necessary speed, manoeuvrability and safety of a MODU under all sailing (operating) conditions without permanent attendance of personnel in machinery spaces.

6.6.2 The propulsion plants are to meet the requirements set forth in 4.2 and other applicable requirements set forth in other Sections of this Part and other Parts of MODU/FOP Rules.

6.7 BOILER PLANTS

6.7.1 The extent of automation of the boiler plant functions and the scope of its controlled parameters to be read out in the main machinery control room are to comply with the requirements set forth in 4.3.

6.7.2 Where there is a local control station with full scope of required functions to control and monitor the boiler plant, common alarms (grouped together according to the most important parameter groups of the same type) and remote emergency shut-down devices may be presented in the main machinery control room.

6.8 COMPRESSOR PLANTS

6.8.1 The automated control system of air compressors is to provide for local and remote (from the engine control room) as well as automatic control based on the compressed air parameters.

6.8.2 The scope of the compressors and compressed air alarms presented in the engine control room is to comply with the requirements set forth in 4.5.

6.9 PUMPING PLANTS

6.9.1 Automated control of electric motors driving the pumps of essential services on the unit is to comply with the requirements set forth in 4.6.

6.9.2 Provision is to be made for remote (from the engine control room) starting and stopping the pumps, as well as for remote control of valves of the essential systems with respective indication of their open or closed position to be presented in the engine control room.

6.9.3 Automated pumping plants of the submersion/raising system of submersible and semi-submersible MODU are to meet the requirements set forth in 9.3.

6.10 BILGE SYSTEMS

6.10.1 Where no provision is made for an automated bilge system in conformity with 4.7, fittings of the bilge well drainage system in machinery spaces are to be remotely controlled from the engine control room.

6.10.2 For bilge systems of machinery spaces the requirements of 4.7.2 to 4.7.5 are to be complied with.

7 DYNAMIC POSITIONING SYSTEMS

7.1 SCOPE OF APPLICATION AND DISTINGUISHING MARKS IN THE CLASS NOTATION

7.1.1 The present requirements cover the electric and electronic equipment and the automated control of the dynamic positioning systems (DP-systems).

7.1.2 Observance of the requirements of this Section and applicable requirements of other Sections of the present Part is mandatory for MODU which are assigned, in conformity with 2.4, Part I "Classification" of MODU/FOP Rules, one of the following marks: **ДИНПОЗ-1**, **ДИНПОЗ-2** or **ДИНПОЗ-3**.

7.2 DEFINITIONS AND EXPLANATIONS

7.2.1 For the purpose of this Section the following definitions have been adopted.

D y n a m i c p o s i t i o n i n g s y s t e m (DP-system) is a complex intended for automatic and remote control of thruster units of the MODU in order to dynamically position the unit with prescribed accuracy under the action of disturbing environmental forces. The complex is to comprise at least the following sub-systems:

electric power supply system;

thruster (propulsor) units to produce necessary vector and magnitude of thrust in order to compensate for environmental effects;

control system consisting of digital computer system with appropriate hardware, information displays, a system of external effect and unit's position sensors, as well as set-point devices.

E l e c t r i c p o w e r s y s t e m is a system intended to supply the DP-system under all operating conditions, including the emergency ones, and comprising:

prime movers of generators with their associated auxiliaries, devices and piping;

generators;

switchboards;

cabling.

The electric power system may be a specialized as well as a common electric power system of the unit.

T h r u s t e r s y s t e m is a system intended to produce and maintain at each instant of time an appropriate hydrodynamic vector and thrust capable of compensating for the environmental effects on the MODU.

The system is to comprise the following items:

electromechanical thruster units with their drives and auxiliaries including hydraulic piping and tanks (if provided);

main propulsion plant of the MODU and rudders if controlled by the DP-system;

electric and electronic equipment of individual control of the thruster units;

manual and automated devices to control jointly all the thrusters;

cabling connected with all the machinery and systems.

D y n a m i c p o s i t i o n i n g c o n t r o l s y s t e m is an electric and electronic programmable system intended to control the thruster units of the MODU and comprising the following components:

computer system with associated software and interfaces;

automated control system of the thrusters with the use of a single control (joystick) or several controls;

system of the unit's position sensors, sensors to detect action of environmental forces on the unit and feedback sensors;

control panel system with controls and information displays;

system to generate parameters of control actions the thruster units have on the MODU and to monitor the prescribed position;

power, information and control cabling.

Redundancy of dynamic positioning system is duplication or multiple redundancy of its components, at which a complex consisting of an electric power supply system and thruster units with their individual control systems functions under control of a computer system in such a way that failure of particular control systems, particular thruster units or components of the electric power supply system does not affect the performance of the task to ensure the MODU position keeping.

Single failure in dynamic positioning system is a failure of any active component (thruster, its local control system, power supply generator, automatically controlled valve) or of any passive component (power or control cable, manually controlled valve, etc).

7.3 SCOPE OF SUPERVISION

7.3.1 The following equipment of DP-systems is subject to supervision during manufacture and service:

electric machines and machinery converters;

power static semi-conductor converters and transformers;

switchboards;

uninterruptible power supply arrangements;

power, control, including information, cabling;

control and monitoring consoles;

switchgear and control gear and protective devices;

computers and computer based systems with software;

unit's position sensor system;

other equipment as may required by the Register.

7.4 TECHNICAL DOCUMENTATION

7.4.1 Prior to the commencement of technical supervision of the DP-system's electric and electronic equipment during manufacture the following documentation is to be submitted to the Register for consideration:

.1 explanatory note with description of the operating principle and justification of the system redundancy level;

.2 list of equipment installed with indication of the devices and units used and their main specifications;

.3 drawings showing layout of the thruster units and cable routing with indication of methods used for cable installation and penetration through watertight and fireproof bulkheads;

.4 general arrangement plans of the control consoles and panels with indication of primary and secondary control stations;

.5 schematic and functional diagrams for power unit control;

.6 functional diagrams for computerized control system with indication of the inputs and outputs with feedback;

.7 self-check system and alarm system;

.8 drawing showing layout and diagram of the unit's position sensors and their connections with control system;

.9 test program for control system;

.10 list of spare parts.

7.5 DESIGN OF THE DP-SYSTEM, CLASSES

7.5.1 The design of the dynamic positioning control system is to conform to the general requirements set forth in Section 2.

7.5.2 Where the main machinery (propulsion plant) and rudder system of a self-propelled MODU form part of the DP-system, the requirements of this Chapter are to be fully applied thereto, in addition to the requirements placed upon the propulsion machinery and rudder system.

7.5.3 The DP-systems are to be subdivided into classes proceeding from the severity of effects due to loss of stable position of the unit.

7.5.4 Class 1 DP-system which corresponds by its characteristics to the mark **ДИНПОЗ-1** in the class notation is a system with minimum redundancy as indicated in 7.5.8.

In this case the loss of position of the unit can occur upon single failure as stated in 7.2.6.

7.5.5 Class 2 DP-system which corresponds by its characteristics to the mark **ДИНПОЗ-2** in the class notation is to have such redundancy that the position keeping ability of the unit is maintained upon single failure in any active component.

This is considered to mean that a failure in any passive component of the system is precluded owing to provision of an appropriate protection against mechanical damages and owing to the component properties confirmed by a Certificate of the Register.

7.5.6 Class 3 DP-system which corresponds by its characteristics to the mark **ДИНПОЗ-3** in the class notation is to have such redundancy that the position keeping ability of the unit is maintained upon single failure of components in the following cases:

failure in any active and passive component, as indicated in 7.2.6, located in different watertight compartments;

failure in active and passive components located in any one of the watertight compartments, due to flooding or fire;

failure in active and passive components located within any of the fire zones, due to fire or explosion.

7.5.7 For Class 2 and 3 DP-systems, the operator error or incompetence is to be considered as a single failure and such failure is not to lead to loss of position of the unit.

7.5.8 Class 1 DP-system is to be designed with redundancy of the following components:

actuating thrusters with their local control systems;

control systems of the complex (one manual control system and one computerized control system);

position sensor system.

7.5.9 Class 2 DP-system is to be designed with redundancy of the following components:

electric power supply system;

actuating thrusters with their local control systems;

computerized control system of the complex;

position sensor system.

7.5.10 Class 3 DP-system is to be designed with redundancy of components as indicated for Class 2 DP-system, but in addition, all the redundant components are to be divided by watertight or "A-60" class fire-resisting bulkheads.

7.5.11 The redundant components ensuring an appropriate reliability of the system are to function continuously or be switched in use immediately, if necessary. Change-over to a redundant component is to be effected either automatically or by simple actions of the operator. The change-over is not to cause excessive fluctuations of the positioning mode.

7.6 ELECTRIC POWER SYSTEM

7.6.1 The power system necessary to supply the thruster units is to have a sufficient capacity and is to respond in time to variations caused by the operating modes needed at the moment.

7.6.2 For Class 1 DP-systems, the power system may be non-redundant.

7.6.3 For Class 2 DP-systems, the power system is to be capable of being divided into at least two independent systems, each having a capacity sufficient to ensure all the operating modes of the thruster units. While in use, the power system may function as a common electric power supply system.

7.6.4 For Class 3 DP-systems, the power system is to have characteristics mentioned in 7.6.3, but moreover, it is to be physically separated by "A-60" class fire-resisting division (bulkhead) into two independent systems. Where the electric power supply systems are located below the operational waterline, they are to be divided by watertight bulkheads. During operation, such systems are to function separately, except for the cases subject to special consideration by the Register.

7.6.5 Where an automated power management system is provided, it is to be designed with redundancy.

7.6.6 The power management systems are to be supplied from both the main and the emergency sources of electric power. Where electric power supplied from one of the power sources is lost, alarms are to be released at the control stations.

7.6.7 The programmable electronic systems (computer based or microprocessor (PLC) systems) are to be power supplied in such a way as to minimize voltage bumps, harmonic interference and to provide protection against erroneous connection (connection with a wrong polarity).

7.6.8 For the DP-systems designed with appropriate redundancy, depending on their class, the following arrangements are to be provided:

.1 the power system is to be equipped with a device to change over automatically to a standby source having appropriate quality characteristics including those regarding stabilization;

.2 the change-over operations are not to interrupt or disturb procedures essential to the safety of the unit;

.3 particular attention is to be given to:

sufficiency of the accumulator battery capacity;

suitability of the charging facilities;

inverter equipment;

load monitoring systems;

protection systems;

earthing systems;

switchgear;

synchronizing devices to provide changeover to standby power sources or standby power supply systems.

7.7 THRUSTERS SYSTEM

7.7.1 Each electric drive of the thrusters is to be power supplied by a separate supply circuit without the use of common feeders or common protective devices and is to be provided with an independent device for emergency shutdown of electric motor actuated from the control station.

7.7.2 Each electric drive is to be provided with its own control system supplied by a separate circuit without the use of common feeders or common protective devices.

7.7.3 Blade position and thrust azimuth (direction) of the thrusters, in the event of the electric drive failure, are to remain unchanged, without marked deviations. Control of a thruster is to be restored manually.

7.7.4 To eliminate electromagnetic interaction between command signals, feedback signals of the local and electronic (computer based) DP-control systems, the said control systems are to meet the requirements set forth in 2.2, Part X "Electrical Equipment" of MODU/FOP Rules.

7.7.5 Each electric and hydraulic control system is to be provided with duplicated power supply via separate circuits without the use of common feeders and common protective devices.

7.7.6 Provision is to be made for standby power supply circuits to 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.

7.7.7 The operations to transfer the power supply of the control systems from the main feeders to the standby ones are not to result in loss of power to equipment and devices.

7.7.8 For the local control system of a thruster and for the computer based control system, separate feedback sensors are to be provided. The feedback channels are not to have common elements the failure of which will results in loss of control from both the one and the other control system. For example, two feedback channels are to have two independent sensors actuated by separate mechanical linkages and cable lines of these sensors are to run with as much separation as practicable.

7.7.9 The feedback signals of various parameters describing condition of the unit, the information on the power consumed to maintain the MODU on station and some other parameters are the most important. The DP-system is to be able to compare these signals, initiate the alarm system in the event of their faults and continue to maintain the unit on station using feedback signals from other sensors.

7.8 CONTROL STATIONS

7.8.1 The main DP-system control station is to be combined with the main navigating bridge control station wherefrom there is a good view of the unit ends and surroundings.

The face panels of the DP-system control consoles are to be equipped with permanent visual alarm and indication of the normal operational status of the following sub-systems:

electric power system (number of running generators and converters, their load, availability of standby sets);

power thruster system (number of thrusters, operating mode, load, status of local control systems);

dynamic positioning control systems (status of main and standby power supply, magnitudes and directions of thrust with reference to the unit axis, indication of its position on station, status of digital computer system and status of the unit's position sensor system, other information needed to ensure safe functioning of the DP-system).

Information regarding other parameters of particular devices and machinery is to be presented to the operator on request.

7.8.2 The display switching system, and controls are to be designed with due regard for the national ergonomic standards. The thruster control mode is to be selectable by simple actions of the operator and the mode selected is to 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 aided) control.

7.8.3 For Class 2 and 3 DP-systems, the controls and electronic control logic are to be such that incompetent or unauthorized actions of the operator cannot cause disturbance of the normal positioning mode.

7.8.4 The alarm system of the DP-system is to meet the general requirements set forth in the present Part.

7.8.5 The alarm system of the DP-system, in addition to audible and visual signals relating to the DP-system machinery and devices, is to contain textual and graphic information on typical failures of the system components and recommendations to the operator with respect of the necessary arrangements to be made in order to keep the position of the MODU.

7.8.6 The dynamic positioning control system is to be designed with a logic that would render fault development and transfer from one system to another impossible. The redundant system components are to interact in such a manner that if one of these components fails, it is isolated (disconnected) and the other component comes into action. The displays are to present sufficient visual and audible information on transfer to the redundant component.

7.8.7 The control system is to provide for quick transfer from the automatic to the remote manual thruster control using both several joysticks (according to the number of thrusters) and a single common joystick. Transfer from the manual to automatic (computer-aided) control is to be effected with similar quickness.

7.9 COMPUTER BASED CONTROL SYSTEMS

7.9.1 The redundancy requirements are not to be applicable to computer systems used in the Class 1 dynamic positioning control systems.

7.9.2 Computer systems used in the Class 2 dynamic positioning control systems are to be duplicated and independent of one another. Faults in common devices, such as interface devices, data transmission units, data buses and software, including self-checking units are not to render the both systems inoperative.

7.9.3 Computer systems used in the Class 3 dynamic positioning control systems are to be duplicated as indicated in 7.9.2, and furthermore, provision is to be made for an independent back-up dynamic positioning control system arranged in a special space separated from the main control station by "A-60" class fire-resisting division. During normal dynamic positioning control the back-up system is to be in a "hot back-up" state in "on" condition and in the automatic input mode of data from the position reference system and feedback sensors of the thrusters, etc. Transfer to the back-up system is to be possible at all times and is to be effected manually from the back-up control station.

7.9.4 For Classes 2 and 3 computer based control systems, provision is to be made for a program of a consequence analysis to evaluate the ability of maintaining the MODU position after failures of DP-system equipment and devices which can bring the unit into the most severe emergency conditions. The analysis program is to confirm that the thrusters which remain operable after a typical failure are able to produce an adequate resultant hydrodynamic vector and thrust required before the failure has occured, under prevailing weather conditions.

7.9.5 Where the consequence analysis program establishes an inability to maintain position of the unit, warning alarm is to be actuated.

7.9.6 When performing operations the completion of which requires a long period of time, the consequence analysis program is to incorporate a simulation function for the magnitudes of the thrust and power demand which will be ensured after a failure that can bring the unit into the most severe emergency conditions, with the data on weather conditions being put in manually.

7.9.7 Provision in the redundant computer systems is to be made for the control function changeover after one of the computer system has failed.

Transfer of the control from one system to the other is to take place without particular disturbing effects on the thrusters while in positioning mode.

7.9.8 Each computer system is to have its own independent uninterruptible power supply system to provide power to the computers within at least 30 min after loss of power supply from the unit's mains.

7.10 POSITION REFERENCE SYSTEMS

7.10.1 Position reference systems for the Class 1 DP-systems are to be based on the operating requirements with due regard for the acceptable performance characteristics.

7.10.2 For the Classes 2 and 3 DP-systems, provision is to be made for at least three independent position reference systems operating on different principles, which are to function simultaneously and co-ordinately in the dynamic positioning control system being in operation.

7.10.3 The position reference systems are to provide position data with adequate accuracy. Provision is to be made for visual and audible alarm to indicate deviations from true data or excessive attenuation of the data signals.

7.10.4 For the Class 3 DP-system, one of the position reference systems is to be connected with the back-up control system and installed in a special space isolated from the other spaces containing the position reference systems by "A-60" class fire-resisting division.

7.11 EXTERNAL FORCE UNIT SENSORS

7.11.1 For the DP-system, provision is to be made for at least the following sensors to measure effects of the forces acting on the unit or the forces themselves:

heading;
magnitude of unit motions;
wind speed;
wind direction.

7.11.2 For the Classes 2 and 3 DP-systems, the external force signals are to come from at least three independent sensor systems for each parameter (e.g. for heading, three gyro compasses are to be provided).

7.11.3 For the Class 3 DP-systems, one group of sensors of each type, in addition to the requirements set forth in 7.11.2, is to comply with the requirement for isolation thereof from other sensors by "A-60" class fire-resisting division.

7.12 ALARM SYSTEM

7.12.1 In addition to the requirements set forth in 2.4, the alarm system is to have facilities to preserve and indicate the "primary fault" data.

7.12.2 The alarm system is to be divided structurally into parameter block which to a certain degree is informative and alarms which, when activated, require immediate actions to be taken by the personnel. The list of the alarms is given in Table 7.12.2.

Table 7.12.2

No.	Parameter	Alarm system	Comments
1	Computer based control system	Fault[1]	Automatic changeover to back-up system
2	Heading	Deviation beyond permissible limit	
3	Position on station	Deviation beyond permissible limit	
4	Power supply system	Fault	
5	Position reference complex	Fault Error Arrangement nonconformity	For each position reference system
6	Gyro compass	Error Non-conformity	Automatic changeover to standby compass
7	Position reference system	Error Non-conformity	Automatic changeover to standby system
8	Wind pressure sensor	Error Non-conformity	Automatic changeover to standby sensor
9	Oil pressure in the hydraulic system "Taut rope"[2]	Minimum	
10	Oil temperature in the hydraulic system "Taut rope"[2]	Maximum	
11	Oil level in the hydraulic system "Taut rope"[2]	Minimum	
12	Deviation signal of the hydraulic system "Taut rope"[2]	Limiting deviation	
13	Total electric power requirements	Excess	Controllable within 50 — 100 per cent
14	Air conditioning system for computers	Maximum	
15	Operating state of main subsystems[2]	Change in state	

[1]The computer based system is to be able to use the last information on position in case when one or more of the position reference systems are faulty or not switched on.
[2]The parameters may be generalized.

7.13 CABLE ROUTING AND PIPING OF DP-SYSTEM MACHINERY AND DEVICES

7.13.1 For the Classes 1 and 2 DP-systems, cable routes of electrical equipment and control systems, as well as hydraulic, fuel and lubricating oil, etc piping are to be installed with due regard for the requirements set forth in 16.8.4, Part X "Electrical Equipment", and 1.6, Part VIII "Systems and Piping" of MODU/FOP Rules.

7.13.2 For the Class 3 DP-systems, cable routes of standby electric and electronic equipment and piping of standby support systems and control systems are not to run together with cable routes and systems of main equipment through the same spaces (compartments). Such installation may be only permissible in cases when the cable routes of standby equipment are laid in "A-60" class fire-protective conduits. No junction boxes are to be permitted in such conduits.

8 ANCHORING SYSTEMS OF MODU

8.1 GENERAL

8.1.1 Anchoring arrangements, where fitted as the sole means for position keeping, are to be designed to maintain the unit on station in all operating conditions. The arrangements are to be such that a failure of any single component (device) is not to cause progressive failure of the remaining anchoring arrangements.

8.1.2 Each anchor winch is to serve only its own anchoring arrangement, with the exception of the passive mooring arrangements served by portable drives which take care of several winches.

8.1.3 Each anchor winch is to be provided with its own independent control system supplied by its own feeder with an individual protective device.

8.1.4 The design of the winch is to provide for adequate dynamic braking capacity to control normal combinations of loads from the anchor, anchor cable and anchor handling vessel during the deployment of the anchors at the maximum design payout speed of the winch.

8.1.5 On loss of power to the anchor winch, the power-operated braking system is to be automatically applied and be capable of holding against at least 50 per cent of the total static braking capacity of the winch.

8.2 CONTROL SYSTEMS

8.2.1 Each winch is to be controlled from a position which provides a good view of the anchoring operations having regard to the laying-out of the anchor by an anchor handling vessel.

8.2.2 Means are to be provided at the anchor winch control position to monitor cable tension and winch power load and to indicate the amount of cable paid out.

8.2.3 A manned control station is to be provided with means to indicate cable tensions and direction of wind. Reliable means are to be also provided at this control station to communicate between all locations critical to the anchoring operation.

8.2.4 Means are to be provided at the local and remote control stations to enable the anchor to be released from the MODU in an emergency. These means are also to operate after loss of main power, being automatically changed over to an independent standby power source, as this takes place. The anchor arrangement control circuits need not to be supplied from an independent power source in this case. Operation of the changing over device is not to cause faults in the power supply system.

8.3 AUXILIARY THRUSTERS FOR ANCHORING SYSTEMS

8.3.1 Where the anchoring systems are used in conjunction with auxiliary thrusters to keep the unit position, the auxiliary thrusters (their power equipment and control systems) are subject to special consideration by the Register.

8.3.2 Applicable requirements placed upon the dynamic positioning systems as set forth in 18.7,18.8 and 18.12 cover also their control systems including centalized microprocessor control.

9 BALLAST SYSTEM OF SUBMERSIBLE AND SEMI-SUBMERSIBLE MODU

9.1 GENERAL

9.1.1 The semi-submersible MODU is to be provided with an effective ballast pumping system capable of ballasting and deballasting any ballast tanks in normal and extreme conditions.

9.2 BALLAST PUMPS

9.2.1 The electric motors of the ballast pumps are to comply with the requirements specified in 5.5, Part X "Electrical Equipment" of MODU/FOP Rules and to be supplied by two feeders: one from the main switchboard and the other from the emergency switchboard.

9.2.2 The ballast system is to be capable of operating after the damage of any one component (generator, transformer) in the power supply system.

9.2.3 The ballast system is to remain operational under conditions when the unit is in damaged condition, has a heel and/or trim which reaches its limiting values as specified in 2.1.2.2 and is supplied from the emergency source of electric power.

9.3 CONTROL AND INDICATING SYSTEMS

9.3.1 A central ballast control station is to be provided on the unit. It is to be located above the worst damage waterline. The control console is to be of protection class not lower than IP-23 and is to be equipped with the following control, alarm and indication systems:

.1 ballast pump control system;
.2 ballast pump status-indicating system;
.3 ballast valve control system;
.4 ballast valve position-indicating system;
.5 tank level indicating system;
.6 draught indicating system;
.7 heel and trim indicators;
.8 power availability indicating system (main and emergency) for control, alarm and indicating systems;
.9 ballast system hydraulic/pneumatic pressure-indicating system.

9.3.2 In addition to remote control of the ballast pumps and valves from the central ballast control station, all ballast pumps and valves are to be fitted with independent local control operable in the event of remote control failure. The independent local control of each ballast pump and of its associated ballast tank valves is to be in the same location.

9.3.3 The ballast pump control and status-indicating systems are to function independently of one another, or have sufficient redundancy, such that a failure in one system does not jeopardize the operation of the other systems.

9.3.4 Each remotely operated ballast valve is to fail to the closed position upon loss of control power. An alternative ballast valve arrangements that do not fail to the closed position upon loss of power may be accepted only with the proviso that this does not result in uncontrolled overflow of ballast which can entail a dangerous situation.

9.3.5 The tank level indicating system required by 9.3.1.5 is to provide means to:

.1 indicate liquid levels in all ballast tanks. A secondary means of determining levels in ballast tanks, which may be a sounding pipe, is to be provided. Tank level sensors are not to be situated in the tank suction lines;

.2 indicate liquid levels in other (non-ballast) tanks, such as fuel oil, fresh water, drilling water or liquid storage tanks, the filling or emptying of which could affect the stability of the unit.

9.3.6 The draught indicating system is to indicate the draught at each corner of the unit or at representative positions.

9.3.7 Enclosures housing ballast system electrical control and monitoring components (units), the failure of which would cause unsafe operation of the ballast system upon liquid entry into the enclosure, are to comply with the requirements set forth in 2.4.4.2, Part X "Electrical Equipment" of MODU/FOP Rules.

9.3.8 Means to indicate whether a valve are open or closed are to be provided at each location from which the valve can be controlled. The indicators are to rely in their functioning on movement of the valve stem or spindle.

9.3.9 Means are to be provided at the central ballast control station to isolate or disconnect the ballast pump control and ballast valve control systems from their sources of electrical, pneumatic or hydraulic power.

9.4 INTERNAL COMMUNICATION

9.4.1 A permanently installed means of communication, independent of the unit's main source of electrical power, are to be provided between the central ballast control station and spaces that contain ballast pumps or valves, or other spaces that may contain equipment necessary for the operation of the ballast system.

9.5 PROTECTION AGAINST FLOODING

9.5.1 On all semi-submersible (column-stabilized) units and on all other units where the spaces containing the seawater valves are normally unattended and not provided with high bilge water level detection, each seawater inlet and discharge in spaces below the assigned load line is to be provided with valves operable from a position above the spaces containing the valves.

9.5.2 The control systems and open/shut indicators of watertight doors and hatch covers are to be operable in both normal conditions and in the event of main power failure. The power supply system of the above arrangements is to comply with the requirements set forth in 5.9.2.

9.5.3 The bilge pumping system is to be provided with a remote control system and its valve position (open/shut) indicators, as well as alarms to indicate high water level in the bilge wells or compartments of the unit. The alarms to indicate high water level in each bilge well are to be activated by two independent sensors. One of these sensors may be used also to activate an automated bilge pump.

10 JACKING ARRANGEMENTS OF SELF-ELEVATING MODU

10.1 GENERAL REQUIREMENTS FOR JACKING ARRANGEMENTS

10.1.1 The jacking arrangements of self-elevating MODU are to be capable of elevating and maintaining the unit in operating condition.

10.1.2 The jacking arrangements are to be designed with sufficient redundancy in such a way that in the event of failure of any one component (unit, set, electric and hydraulic power system, control system) they remain able to continue to elevate or retain the unit in initial position.

10.2 DESIGN

10.2.1 The jacking arrangements are to be so designed as to preclude overloading of their parts, assemblies and machinery at any unit operations. This is particularly true for the following electrical equipment components:

controllers (starting gear) of electric motors;

characteristics of electric motors (rating, torque);

characteristics of brakes;

interlocks between electric motors and fixing devices of legs.

10.2.2 The braking system is to be automatically applied upon loss of power to the jacking arrangements.

10.3 FIXING DEVICES

10.3.1 For a self-elevating MODU not provided with leg fixation system, calculation of the brake holding force is to be made with due regard for maximum load defined as a maximum interaction between the leg and self-elevating mechanism under storm conditions (maximum mass of the unit plus the relevant component of storm action). The static braking torque is to be taken to be not less than 1,3 times the maximum load having regard to the mechanical transmission efficiency.

10.3.2 For a self-elevating MODU provided with leg fixation system, calculation of the brake holding force is to be made with due regard for the design load. The static braking torque is to be taken to be not less than 1,2 times the design load.

10.4 ELECTRIC MOTORS OF JACKING ARRANGEMENTS

10.4.1 The power of electric motors driving the jacking arrangements is to be chosen with consideration for the possible, within permissible limits, nonuniform distribution of the design load throughout the unit, having regard to the design permissible time of unit elevation, as well as having regard to the losses by friction between the legs and guides and to the reduction gear efficiency.

10.4.2 The characteristics of the electric motor torque (mechanical characteristics) are to be such as to render the electric motor incapable of causing damage to any part (component) of the reduction gear or gear rack of the jacking mechanism in the event of mechanical interlocking of the jacking system.

10.5 CONTROL AND MONITORING SYSTEMS

10.5.1 To ensure control of elevation or lowering of the unit, the control stations are to be fitted up with appropriate monitoring system which is to provide for an alarm to be activated in the event of deviations from the permissible values and indication of at least the following parameters:

availability for elevation/lowering operation (power to all necessary equipment is turned on);

position of fixing devices (catches) of legs (if provided);

load on legs;

deviation from horizontal position of the unit;

pressure of working fluid in hydraulic cylinders;

pressure of working fluid in control system;

temperature of working fluid in hydraulic system;

loading (current) of electric motors;

overloading of electric motors.

10.5.2 In order to equalize the loads between the jacking mechanisms of the legs, the torques developed by the electric motors are to be monitored and equalized whenever necessary. This procedure is to be carried out after elevation of the unit as well as in storm conditions where the load distribution can be disturbed. Such procedure does not apply if an automatic load distribution system is available.

10.5.3 In the electric drives of each leg, one feeder is allowed to supply two or more motors. The feeder is to be provided with short-circuit protection set to operate at not more than ten-fold value of the total full load current of the motors jointly switched on.

10.5.4 Monitoring of the motor loading required by 10.5.1 is to be effected by three-phase wattmeters with a central scale. Such wattmeters may be installed not for each motor but for the feeder to which two or more jacking system motors are connected.

10.5.5 The seawater supply system is to provide for monitoring of at least the following parameters:

water pressure in system (minimum pressure alarm and pressure indication in the engine control room);

water level in intermediate tank;

submersible pump and pipe position indication;

automatic stoppage of mechanism for lifting and lowering submersible pumps in end positions.

10.5.6 Provision is to be made for automatic start of a standby submersible seawater pump in the event of water pressure drop with an alarm signal to be released in the main machinery control room.

PART XV. MODU AND FOP SAFETY ASSESSMENT

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of this Part apply to the MODU of self-elevating and semi-submersible types, as well as to the fixed platforms including ice-resistant and tension leg units.

1.1.2 The MODU/FOP Rules cover the accident situations of the following kinds:

extreme hydrometeorological conditions;

earthquakes;

collisions with ships and other floating objects;

helicopter accidents;

dropped objects;

explosions;

fires;

blowouts;

combination of these;

violation of safety requirements, incompetent management with the change of conditions, poor maintenance;

other potential situations.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 The definitions and explanations relating to the general terminology are given in Part I "Classification" of MODU/FOP Rules.

1.2.2 In the present Part, the following definitions have been adopted.

Safety is a property to retain a capability of performing specified functions under specified operational conditions through-out the specified time period wherein an impact of hazardous and harmful factors on the platform, its components, the environment and attending personnel is prevented or reduced down to tolerable values.

Hazard means a condition (natural or of the technosphere) wherein the phenomena or processes, which may strike people, cause a material damage or affect the environment, are likely to occur.

Hazard identification means a process of identifying and recognizing an existing hazard, as well as a definition of hazard characteristics.

Accident is an unintended event (occurrence) whose emergence is not expected in the course of platform normal functioning and which may cause substantial damages to a structure if it is not taken into account during design.

Accident situation is an operational situation during which an accident may materialize.

Accident scenario means a complete and formalized description of the following events: an accident initiation phase, an accident process and emergency situation, losses in accident including specified quantitative characteristics of accident events, their space-time parameters and causative links.

Catastrophe means an extraordinary in its consequences event (accident) like a widespread disaster resulting in the platform loss, casualties or environmental damage.

Risk is a frequency of hazards (of a certain class) materialization. The risk may be defined as a frequency or probability of event B initiating with the occurrence of an event A (a non-dimensional quantity ranging between 0 and 1).

Risk assessment means a process of hazards identification and risk evaluation as to the people, platform and environment. The risk assessment lies in the use of all available information for hazards identification and risk evaluation for a predetermined event (an accident and related situations) due to these hazards.

Individual risk is a risk (frequency of occurrence) of striking effects of a certain kind occurring during the materialization of certain hazards on a certain platform. It defines the distribution of risk.

AIR means annual individual risk.

Societal risk is a function of risk (frequency of events occurrence) to strike the certain number of people exposed to striking effects of a certain kind during the materialization of certain hazards, of this number of people. It defines the extent of a catastrophic hazard for a platform.

Running a risk means an individual or a social group on whom the effect of a certain kind may be exerted during the materialization of a certain hazard or hazards, i.e. for whom the individual or societal risks are not null or, alternatively, reach a certain level.

QAR means quantitative assessment of risk.

"Continuously or frequently" means that an event happens continuously or may frequently happen during the service life of a given platform.

"Not frequently" means that an event may happen several times during the service life of a given platform.

"Infrequently" means that an event is not to happen during the service life of one platform, but it may happen on separate platforms of the same type during their service life.

"Very infrequently" means that an event is not of, but nevertheless may happen during the common service life of the certain number of the same type drilling platforms.

Area of tolerable level of accident and their consequence risks means the materialization of an as low as reasonably practicable (ALARP) level.

Event tree is a graphic technique ensuring a qualitative description of potential accident situations, as well as quantitative assessment for each tree branch, and is an inductive method.

Error and fault tree is a graphic technique which permits to trace all the logical interconnections between technical faults, environmental conditions and human errors resulting in the event in question, and is a deductive method.

FN curves present the level of an accident frequency plotted against the number of people killed in accident.

Operational standard is a document stating the functioning parameters required for the structure, systems, equipment, personnel and procedure for safety control.

1.3 GENERAL PRINCIPLES OF PLATFORM SAFETY CONTROL

1.3.1 It is assumed that design, calculations, structure, platform operation and maintenance meet all the Register normative documents in force.

1.3.2 Safety assessment on the basis of a platform conceptual design is to be included in the general plan of design development and platform construction.

1.3.3 As a basis for safety assessment, a designer is to submit the following information:

description of the platform environment;

description of the platform functioning and operational details;

layout drawings showing arrangements and systems performing the most essential functions. Particular emphasis is to be placed on the locations wherein works are performed and the equipment, having a significant destructive potential, is installed, as well as on fire safety, accommodation complexes, escape routes, protective zones and evacuation systems;

key structural diagrams;

description of the most important measures provided for accident probability reduction;

description of measures provided for restriction of accident consequences;

description of escape routes;

description of the level of safety associated with new processes and technical innovations planned for use;

specified emergency cases corresponding to design emergency effects on platform parts described in Section 2;

calculation showing that the consequences of design extreme environmental conditions and emergency effects meet adequate safety criteria specified in Section 5.

1.3.4 The assessment of platform safety is, first of all, to be conducted at the level of the design conception while selecting the platform type. It is assumed that the designer has selected the most favourable design decision, which meets the general principles of safety.

The meaning of this assessment is to make sure at the early design stage that the platform conception selected does not result in necessity to introduce principal alterations in design and construction due to the safety requirements. The objective of the safety assessment is to ensure acceptable safety in accordance with the set criteria.

1.3.5 The safety assessments regulated in the MODU/FOP Rules are to confirm the reasonably lowprobability of casualties evaluated by the use of annual individual risks, and also of societal risks (see 3.2 and 5.3), of large losses (see 4.2) and unacceptable environmental pollution that may happen as the accident outcome (see 4).

Supposedly, the platform that meets the assessments obtained in a conceptual design, and also the criteria of sufficient safety specified in MODU/FOP Rules, will have the necessary safety level.

2 RISK IDENTIFICATION

2.1 CONCEPTION OF ACCIDENT SITUATION ANALYSIS

2.1.1 The analysis of accident situations falls into two main trends. The first one deals with the analysis of accident situations through conformity to standards (the MODU/FOP Rules, Guidelines on Technical Supervision of Mobile Offshore Drilling Units in Service, etc), and the second one, with the analysis of accident situations either for poorly studied scenarios or scenarios of a higher risk.

The analysis of an accident situation opportunity is an additional step destined for assessment of new and considerably different arrangements, equipment, processes, procedures and techniques whose nonconformity to standard practices may be significant. This analysis is to be used for definition and assessment of unexpected accident situations and unintentional actions, which may cause accidents.

The analysis of an accident situation opportunity consists in some measures to keep the platform accident probability and consequences to a minimum. The sequence of the measures is usually as follows:

.1 determination of potential accident situations;

.2 assessment of the risk level to be accepted;

.3 elimination or prevention of accident situations.

The objective of the first and most important measure is the determination of accident situation types (see 2.2); of the second measure, the evaluation of the risk of an identified accident situation for the personnel, platform and environment (see 2.3, 2.4, 3.1 and 3.2); and of the third one, the elimination of prevention of an accident when the risk level was recognized as unacceptable (see Sections 4 and 5).

2.2 TYPES OF ACCIDENT SITUATIONS ON PLATFORMS

2.2.1 General.

2.2.1.1 The analysis of accident situations is performed regularly to identify, evaluate and control potential accident situations on platforms. The thorough and precise assessment of potential accidents on platforms will keep to minimum personnel injuries, equipment losses and environmental threats.

Taken alone, the analysis of accident situations does not ensure the proper level of safety on a platform. It is only the part of a general safety system. Other areas elating to this system are industrial safety, personnel training and a response to accidents.

The analysis of accident situations is used in design (since a design conception), construction and operation of a platform. In this case, all the design modes of operation is to be considered: transportation, in-place installation, operational mode, survival or extreme loading, removal from location, etc.

The analysis of accident situations is also to be applied to existing platforms if they are subjected to major modifications.

2.2.1.2 The general trend of the accident situation analysis is the desire to define the potential hazards associated with development of the accident situation, and the actions on detailed assessment of risk related to an accident. Most of these techniques are complicated, expensive and take a good deal of time, but they may be justified by the safety level and accident consequences.

2.2.1.3 The analysis of potential accident situations is to be approved by the Register and to include the following:

.1 description of conditions at the beginning of an accident situation, initial data for analysis;

.2 description of measures to fight accidents, platform equipment and systems specified for mitigating accident consequences;

.3 information on analysis techniques, physical and statistical models;

.4 description of the accident development process including its design presentation;

.5 protective measures for personnel and individuals present on board a platform in accident.

2.2.2 Potential accident situations for all MODU/FOP.

2.2.2.1 In extreme environmental conditions:

various structural faults in working position due to unintended development of events;

shifting, capsizing and subsidence of a platform on the seabed under the unfavourable combination of environmental conditions and soil properties changed;

transportation of the platform in conditions that do not correspond to acceptable ones by strength criteria and structures reliability;

significant fatigue damages due to severe sea, wind, ice and seismic effects;

brittle fractures in low temperatures and pulse loads.

2.2.2.2 In collision with a ship or floating object.

The process of formation of the ship and platform interaction force in collision is described by the formula

$$N = N_s + N_d \qquad (2.2.2.2\text{-}1)$$

where N = total effect;
N_s = static force (running aboard);
N_d = dynamic force (impact);

$$N_d = M\ddot{X} + B\dot{X}$$

where M and B = inertia and damping factors in collision with a ship, respectively;
$\ddot{X}$, $\dot{X}$ = acceleration and speed of a ship relative to a platform recorded at the instant of collision.

An impact momentum, if the additional requirements are not specified, is

$$N_d \cdot \Delta t = M\dot{X} \qquad (2.2.2.2\text{-}2)$$

where Δt = collision time that depends on the extent and effectiveness of collision objects protection against an impact.

Two types of collision are to be considered:

running aboard of a ship or floating object, i.e. the touch of a platform external surface by a ship or floating object at low speed, usually $\leqslant 0,3$ knots; the factors on the speed and inertia components of the impact are negligible (an impact momentum is nil); the effect may be considered as generated by the impressed force applied statically;

collision with a ship or floating object i.e. the impact of a ship or floating object on a platform external surface; the factors on the speed and inertia components of the effect are sufficient to generate an impact momentum.

2.2.2.3 With explosions, dropping and flying object.

2.2.2.3.1 The main external and internal sources associated with the effect of explosions, dropping and flying objects (fragments) on a platform are:

a helicopter accident;

accidents on support ships and tankers nearby a platform resulting in explosions and/or emergence of flying objects;

pressurized vessels (bottles) and pipelines containing gas or liquid explosive media;

structures and equipment having significant potential energy.

2.2.2.3.2 A flying (dropping) object exerts a mechanical effect on an object (structure, equipment and personnel). The extent of its hazard (striking effect) is primarily defined by the object mass and rate of fall. In addition, the striking effect of the flying object depends on its shape, an angle between a velocity vector direction and an impact plane, etc.

The effect of an explosion on the object is caused by the quick change of an excess air pressure, particularly, in the form of an air shock wave. The level of an air explosion hazard is characterized by the value of the maximum excess pressure. However, in order to assess the object response to an explosion effect, the time of excess pressure build-up and fall is to be determined. The destruction (failure) of some potential explosion sources may be accompanied by simultaneous formation of an excess air pressure and generation of flying objects (fragments). For instance, it takes place in explosion failure of pressurized vessels (bottles).

A helicopter accident along with the mechanical (impact) effect of a fuselage (or other helicopter parts) on platform structures and equipment may be accompanied by an explosion of fuel vapours. Account is to be taken of the explosion possibility both outside and inside platform spaces. The internal explosion usually results in a significantly larger scale accident.

2.2.2.3.3 The possible primary effects (factors) associated with an explosion, dropping (flying) objects and a helicopter accident:

deformation, damage, destruction of structures and equipment;

injuries and fatalities among personnel;

motion (shaking) of structures;

generation of flying objects;

emergence of caustic toxic gases and aerosols;

fire.

The primary effects, in its turn, may give rise to the new set of similar secondary factors. Thus, for instance, shaking of structures may cause equipment damaged, unsecured objects fall, personnel injuries due to falls, etc;

2.2.2.3.4 Three levels of an explosion and flying (dropping) object hazard are set:

I — features the maximum possible values of striking factor parameters and characteristics for a given source;

II — features the values of striking factor parameters and characteristics not relating to the levels I and III;

III — features the values of striking factor parameters and characteristics which do not cause appreciable consequences for platform structure, equipment and personnel and, therefore, for the natural environment as well.

Where the values of striking factor parameters and characteristics for a given source cannot be determined with the adequate degree of reliability, a conservative approach for safety assessment is to be used assuming that the level I hazard is materialized.

2.2.2.3.5 The level III hazard is defined by tolerable levels of loadings on structures, equipment and personnel.

The following loading levels on personnel may be accepted as tolerable:

tolerable levels of accelerations (for sitting and standing positions) — 0,9g (along all the coordinate axes);

at the impact of a head against an obstacle, the collision velocity is not to exceed 2,3 m/s;

at impacts by objects having a mass of 1, 2, 3, 4 and 5 kg the impact velocity is not to exceed 5; 3,7; 3; 2,5 and 2,2 m/s, respectively;

the value of an excess pressure of a shock wave is not to exceed 35 kPa.

2.2.2.4 In fires and blowouts.

2.2.2.4.1 Fires on MODU/FOP are in principle subdivided into two categories:

on the exposed deck caused by an oil and/or gases blowout from a well;

in internal spaces.

2.2.2.4.2 To identify fire risk, MODU/FOP depending on the functions performed (what defines the potential level of a structure hazard) are subdivided into three groups:

oil storage platform;

production platform;

exploratory drilling unit.

Considering 2.2.2.4.1 the qualitative risk matrix shown in Fig. 2.2.2.4.2 may be recommended for use accordingly.

2.2.2.4.3 A fire on an exposed deck caused by an oil and/or gases blowout from a well is to be classified as the most hazardous (see Fig. 2.2.2.4.2). The particular hazard of this fire is that firstly, the oil spread covers a large area; secondly, the influx of a combustible liquid and/or gas is reasonably large and practically uncontrollable, at the initial stage of the fire in particular; thirdly, in the air above the unit a gaseous combustible mixture is formed which consists of air, gases coming from a well and oil vapours as well.

The sources of such combustible mixture ignition may be:

faulty deck lighting;

open flame;

sparks of any origin;

exhaust combustible gases;

combustible parts of equipment.

This fire may follow various scenarios and a sufficient number of various factors may affect fire propagation. In relation to the above, in order to assess risk in fire, logic diagrams of accident development are to be used basing, for example, on constructing event trees. In constructing the logic diagram the following is to be considered first:

level of a structure hazard (see 2.2.2.4.2);

chemical composition of potentially ignitable substance (oil/gas-condensate);

environmental conditions of an operation area (first of all, wind);

actual capabilities of killing a well;

presence of other structures (primarily, permanently manned) near the platform;

possibility of a follow-up explosion;

technical condition of the MODU/FOP hull;

effectiveness of fire protection functioning etc.

It is also to be taken into account that a given fire may cause an oil spill fire and a fireball. Regarding an effect on a human, the striking factors like direct fire effect, excess pressure and heat emission are to be considered.

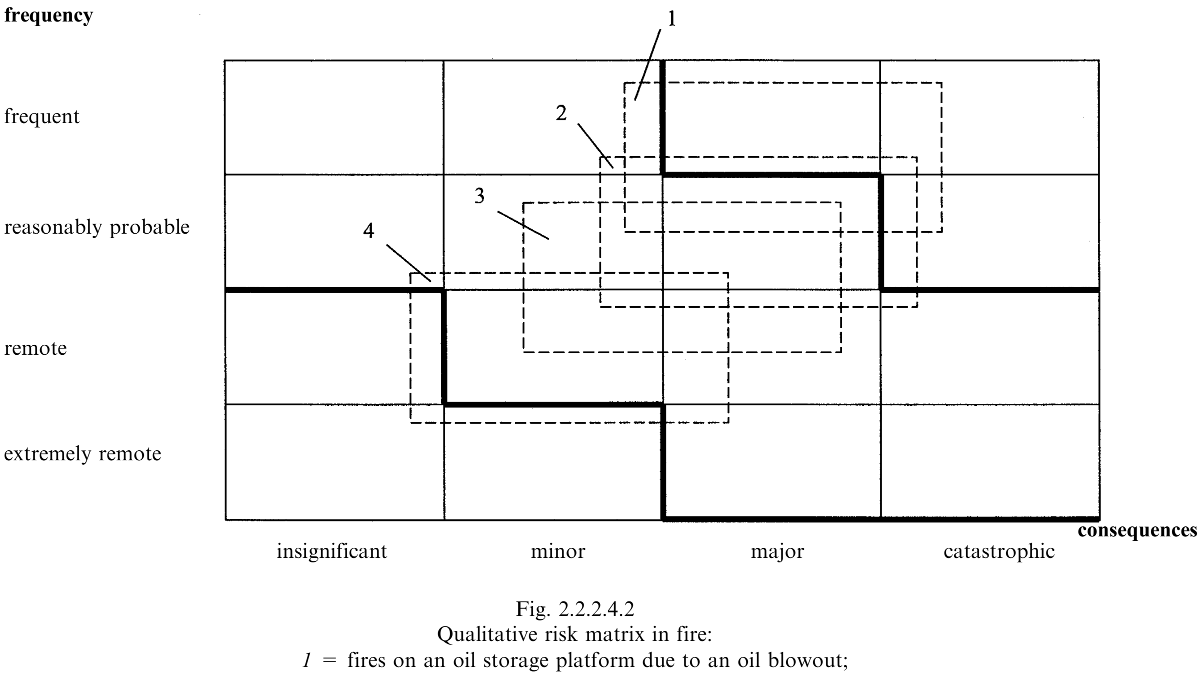


Fig. 2.2.2.4.2
Qualitative risk matrix in fire:
1 = fires on an oil storage platform due to an oil blowout;
2 = fires on a production platform due to an oil blowout;
3 = fires on a MODU due to an oil blowout;
4 = fires in internal spaces

2.2.2.4.4 Fires in MODU/FOP internal spaces may be divided into three main groups:

fires in energy compartments (except purely electrical compartments and spaces);

fires of electrical equipment;

fires in service and accommodation spaces.

The main reasons of fire emergence in internal spaces are:

violation of operating conditions and regulations for equipment and devices operation;

accidents and failures of equipment, machines, machinery and devices, as well as of their service systems.

The source of fire emergence in internal spaces may be:

sparks of any origin;

open flame;

surfaces heated up to a temperature of fuels and lubricants ignition (uninsulated parts of gas exhaust, overheated bearings, electrical equipment);

faulty electric wiring.

2.2.3 Specific accident situations for platform.

2.2.3.1 Self-elevating units.

2.2.3.1.1 All types of accident situations according to 2.2.2 may be materialized with regard to self-elevating units.

2.2.3.1.2 Specific potential accident situations for self-elevating units may be:

subsidence of legs during embedding into the seabed;

jamming of a jacking system during platform hull elevation into an operating position;

scouring of the seabed by bottom currents;

fluidization of the seabed under changing loads;

capsizing and shifting of the platform, as well as the subsidence of legs under wind and wave loads, and as the result of the impact of a ship or other floating object on the leg;

cockings and the break of integrity of the legs when pulled out from the seabed;

sliding apart of the legs in the soil under the unfavourable combination of external loads and the peculiarities of seabed response;

catastrophic consequences of damage to one of the legs of a three-leg unit;

gas blowouts accompanied by a spring in way of the legs;

seizure of the platform hull midway of elevation or lowering on the legs;

failure of elevation machinery;

damage to structural elements of the legs due to collision with a ship or other floating object;

catastrophic consequences, as the result of an earthquake, in connection with changed properties of the base.

2.2.3.2 Semi-submersible units.

2.2.3.2.1 All the types of accident situations according to 2.2.2 may be materialized with regard to semi-submersible units. The specific feature of these units is that the accident situations associated with earthquakes are not applied to them.

2.2.3.2.2 Specific potential accident situations for semi-submersible units may be:

damages (residual deformations, break of integrity) to structural elements of pontoons, stability columns, bracings, upper hull and their joints;

floating of a void compartment;

leakage of oil products;

inclination of the semi-submersible unit hull;

breakage of anchor chains;

combination of the above accident situations.

2.2.3.3 Fixed offshore platform (FOP).

2.2.3.3.1 All the types of accident situations according to 2.2.2 may be materialized with regard to FOP.

2.2.3.3.2 Depending on the architectonic-constructive type of the FOP, specific potential accident situations for them may be:

damages (residual deformations, break of integrity) to structural elements of the hull;

leakage of oil products;

scouring of the seabed by bottom currents;

fluidization of the seabed under changing loads;

shifting of the structure;

capsizing of the structure;

subsidence of the structure at large or its individual parts;

crawling of the ship's end onto the platform inclined side;

collision of the FOP operating in the northern area with an iceberg or grounded ice;

combination of the above accident situations;

loss of stability on the seabed as the result of an earthquake.

2.3 ACCIDENT SITUATION ANALYSIS TECHNIQUES

2.3.1 Checklist.

Use of checklist is a usual method for identification of compliance with standards. The exemplary checklist for the analysis of an accident situation on a mobile offshore drilling unit is given in Appendix 1.

The checklist is simple for use and may find application during design, construction, operation and an accident situation. The minimum acceptable level of hazard is determined with the help of the checklist.

Where necessary, checklists may be drawn up for specific situations and used for assessment of proper execution of standard industrial operations and for specifying the problems to be emphasized.

The checklist is the most quick and simple method for analysis of an accident situation and very effective in the process of standard accident situations management.

2.3.2 "What if... " analysis.

This method is much like the one of checklists use.The method is based on the questions, which begin with "What if... " and considers situation development after "What if... ". The compilers of the analysis are to be very cautious and adequately realistic so as not to think of improbable schemes of events development.

The "What if... " type analysis may be used during design, modification or operation of a drilling platform. Its result is the list of problem locations potential for accidents and the methods supposed for accidents avoidance and prevention.

2.3.3 Hazard and operability (HAZOP) studies.

A multidisciplinary team is to take part in these studies which define accident situations and platform operability using the structural form of the "What if... " type analysis.

The constructive decision on each component of a process scheme is analyzed in the form in which it is presented in design documentation.

The HAZOP method may be used during design, modification and operation of a platform. The result of the analysis is the list of problems associated with potential accidents or reduction in platform operability, as well as the types of malfunctions and consequences of each one.

2.3.4 Event tree analysis.

The event tree analysis is an inductive method intended for a study of accident roots and identification of key errors that initiated the accident. It also provides analysts with the base for accident risk definition.

The event tree analysis consists in constructing the sequence of events (tree branches) causing the top event (event at the top of a tree). Some examples of event trees are given in Appendix 2.

This method is used during design, modification and operation of a platform. It is particularly useful in analysis of new technologies, structural decisions and operational conditions, which have not passed an evaluation test in practice yet. The method ensures:

qualitative description of potential problems including potential event combinations;

quantitative assessments of events frequency for each tree branch which allow to determine the contribution of each event to risk assessment.

2.3.5 Error chain (fault tree) analysis.

A fault tree analysis is a deductive method that focuses on a particular event resulting in an accident, which is called the top event, and on the construction of the logic diagram of all the relationships that may cause this event. The error chain is a graphical illustration of various structural faults, equipment malfunctions, the effect of environmental conditions and human errors, which may cause an accident.

Some examples of error and fault trees are given in Appendix 3.

2.3.6 Studies of operability of platforms in accident situations.

This method may be used during platform design, modification and operation. These studies result in the list of problems, which may cause a potential accident, or reduction of platform operability, as well as in the list of recommended changes, proposals or actions aimed at safety or operability improvement. This method time and effectiveness directly depend on the platform size and complexity and on expertise of specialists who define accident situations and platform operability using the structural form of the "What if... " analysis (see 2.3.2).

2.3.7 Analysis of faults and their consequences.

This analysis is used in definition of individual types of faults, which may cause or contribute to accident occurrence. The analysis of the type of faults and of their consequences may by used along with other ways of hazard identification, such as described in 2.3.5.

The purpose of this analysis is the definition of fault types and of each fault consequences for a platform. At the design stage, this method may be used for identification of needs in additional protective measures or in their reduction. The fault analysis during platform modification is used for definition of its impact on existing structures and equipment. This method is also used in operation for definition of individual faults that may result in significant consequences.

So far as this method is subjective, at least two specialists competent in processes and equipment are needed for its use.

Where each type of faults is included in the analysis of a criticality level, the method goes over into a critical analysis of types of faults and of their consequences.

3 METHODS OF QUANTITATIVE ASSESSMENT OF RISK (QAR)

3.1 STATISTICAL MODELS OF ACCIDENT SITUATIONS

3.1.1 The purpose of risk assessment is to focus attention on areas of the highest risk levels, and also to identify factors having an important effect on them. In addition, the purpose of risk assessment is the establishment of a relationship between the IMO regimes and accident consequences to provide a possibility for introducing regulatory changes for risk reduction.

3.1.2 Among accident situations under consideration are to be those, which allow identifying different types of risks (to people, the environment, structures and equipment).

3.1.3 The purposes of risk assessment stated in 3.1.1 can be achieved, firstly, by constructing so-called event trees (see 2.3.4) and error trees (see 2.3.5). In addition, other appropriate methods (see 2.3) may be used.

3.1.4 The quantitative assessment of contributions to risks is typically undertaken in three stages using available accident statistics:

the categories and sub-categories of accident are quantified in terms of their recurrence (frequency);

the magnitude of accident outcomes is quantified in risk terms;

the distribution of outcome magnitudes across all the sub-categories of accidents is determined in risk terms, so as to evaluate which sub-categories contribute how much risk.

3.1.5 The mathematical technology of QAR may comprise different statistical models including the Bayesian statistics, Monte Carlo method, composite probability formula and other adequate statistical techniques.

For example, the composite probability formula in determination of QAR_k in written down as follows:

$$QAR_k = \sum_{i=1}^{i=n} Q_i Q_{ik} \qquad (3.1.5)$$

where Qi = recurrence of the i-th situation (accident event) under consideration;
Q_{ik} = risk of an accident (as example, a probability of materialization for the i-th branch of an event tree if the method specified in 2.3.4 is used);
n = number of scenarios (events) being considered for the given kind of an accident (or the number of event tree branches);
k = consistent with the given kind of an accident.

3.1.6 The statistical models corresponding to the description of platforms responses to environmental effects (wind, sea, currents, ice, seismic effects) are not to contradict those used in MODU/FOP Rules.

3.1.7 Impact diagram.

An impact diagram is most commonly used for comparison of some versions of a solution. Emphasis is to be placed on the higher risk area. In these cases, the diagram that materializes the proposal based in a table-matrix, may be applied.

Both quantitative and qualitative results can be obtained on the basis of Table 3.1.7.

Table 3.1.7

Taype risk matrix*

Frequent	8	9	10	11
Reasonably probable	6	7	8	9
Remote	4	5	6	7
Extremely remote	2	3	4	5
↑ frequency consequences →	Insignificant	Minor	Major	Catastrophic

* Terms are defined in 5.2.

3.1.8 The risk assessment results in:

identification of high risk areas;

re-evaluation of risk for each risk control option identified in the following third step of formal safety assessment (see Section 4).

3.2 EVALUATION OF INDIVIDUAL AND SOCIETAL RISKS

3.2.1 In the analysis of accident situations, the individual risks featuring the frequency of emergence of striking effects of a certain kind are determined.

The value of an annual individual risk AIR_k at any effect or an accident event is determined by the formula

$$AIR_k = \sum_{k=1}^{i=n} Q_i Q_{ik} Q_{ik}^p \qquad (3.2.1)$$

where Q_i, Q_{ik}, and n = see 3.1.5;
Q_{ik}^p = conditional probability to affect people in materialization of the i-th branch of an event tree.

3.2.2 The value of the total annual individual risk AIR_Σ at various effects (e.g. due to an earthquake, fire, explosions, dropped objects, etc.) is determined as the sum of AIR for separate effects, i.e.

$$AIR_{\Sigma} = \sum_{k=1}^{k=m} AIR_k \quad (3.2.2)$$

where m = number of potential striking factors taken into account.

3.2.3 Societal risk is evaluated with use of *FN* curves connecting the level of an accident frequency (F) with the number of people killed in accident (N).

The societal risk assesses the magnitude of potential catastrophes. It is an integral characteristic of the materialization of certain kind consequences. The value of the societal risk (i.e. fatality risk) at $N = 1$ is used for determining the annual individual risk. The example of *FN* curves construction is given in Appendix 4.

3.3 RECOMMENDATIONS ON EVALUATION OF CATASTROPHE RISK AFTER STRUCTURE DAMAGE

3.3.1 These recommendations are to be considered as an addition to the analysis of an accident risk (see 3.1). Preference is to be given to the accident events that may result in catastrophic consequences (see 5.2).

The recommendations may be used for analysis of already happened events to accumulate experience, during platform operation, as well as in design as a forecast.

3.3.2 A catastrophic risk P may be determined by the formula

$$P = P_1 + (1 - P_1)P_2 \quad (3.3.2)$$

where P_1 = accident risk (corresponds to Q_{ik} in 3.1.5 if the risk of the accident consequences P_2 in accordance with the recommendations of 3.3.4 is not taken into account in this quantity);

P_2 = accident consequences risk determined on the basis of the recommendations stated below.

In determination of quantitative catastrophe characteristics QAR_k (see 3.1.5) and AIR_k (see 3.2.1) it is to be assumed

$$Q_{ik} = P. \quad (3.3.2)$$

3.3.3 The algorithm is constructed as follows: it is assumed that an accident has happened, a structure has suffered a damage (damages) and further, the consequences of this damages are analyzed. The algorithm is based on structural adequacy (see 4.1.6) because the loss of the structure will eventually result in fatalities and damage to the environment.

3.3.4 In evaluation of damage consequences, the following problems are recommended for consideration.

3.3.4.1 Damage identification.

At this point, the question is to be answered: has the given damage been taken into account during platform design (i.e. to what extent it complies with the design damage). In practice, it is precisely design damages that are quite difficult to materialize. Some deviations will always take place.

Working the problem, at least the following questions are to be answered:

were the direct calculations of damaged structure strength performed during platform design and which damage versions were considered;

which margin of survivability (in terms of structural redundancy) has the structure.

3.3.4.2 Evaluation of technical condition of a structure as a whole.

The key question: how much did the technical condition of a structure meet the requirements of normative documents prior to suffering a damage (practically, a moment before suffering a damage). The actual technical condition of the offshore platform hull may adversely effect damage spread as well.

Answering this question, the following is to be known:

age of an offshore platform;

is an active system for evaluation of and watch on structure behaviour available on the platform (monitoring of cracks, deformations, etc.);

date of the last survey or inspection for defects of the platform hull conducted, survey (inspection) results: residual thicknesses, residual deformations, cracks, fractures, presence of obviously weakened zones and in the damage area in particular;

was any deviation from the requirements of normative documents allowed in assessment of residual thickness and deformation vales (if so, how much are deviation data justified?);

was the repair of structural elements conducted;

repair quality;

what time was offshore platform service prolonged for after a survey.

3.3.4.3 Evaluation of environmental conditions.

The key question: will external loads (sea, ice, other environmental loads) exceed or not exceed the design ones for a damaged platform. The case in point is the platform life time after the damage.

Working the problem, the following is worth to regard:

period of the year when a damage has occurred because the probability to exceed the design value of a load changes within a year;

time period needed for taking measures to prevent a potential catastrophe;

is an active system for evaluation of environmental conditions (wind sea, ice, seismic effects, etc.) available on the platform.

In the final, a realistic forecast of environmental conditions is to be available.

3.3.4.4 Evaluation of the possibility of a failure for systems and arrangements such as: anchor lines, a dynamic positioning system, etc. This problem is particularly topical for mobile offshore platforms, and also for platforms in transit conditions.

Working the problem, it is worth to have the following information on:

actual technical condition of systems or arrangements;

environmental conditions after platform structure damage.

The solution of problem 3.3.4.4 is associated with that of the 3.3.4.3 problem with regard to evaluation of environmental conditions.

3.3.4.5 Evaluation of the possibility to damage other elements of the platform hull.

The solution of this problem is associated with that of the problems 3.3.4.1 (as far as structural redundancy is materialized in platform design), 3.3.4.2 (technical condition of structural elements within a damage area and zones of potential emergence of other damages) and 3.3.4.3 (as far as is realistic to exceed design environmental conditions).

3.3.5 The materialization of the algorithm on assessment of damage consequences may be carried out by construction of an event tree. The event tree, recommended as the type one, is presented in Table 3.3.5. Items 1, 2, 3, 4 and 5 of the event tree correspond to the key problems defined in 3.3.4.1 to 3.3.4.5.

3.3.6 Working the algorithm on assessment of damage consequences, available experience of offshore platform design and operation has been taken into account. Further accumulation of the experience is to facilitate algorithm development.

3.4 EXPERT ANALYSIS TECHNIQUES

3.4.1 Delphi technique.

Using the Delphi technique, an "informed intuitive judgement" is materialized, and for this:

a problem is formulated;

a team of experts, who can comprehensively cover the formulated problem, is selected;

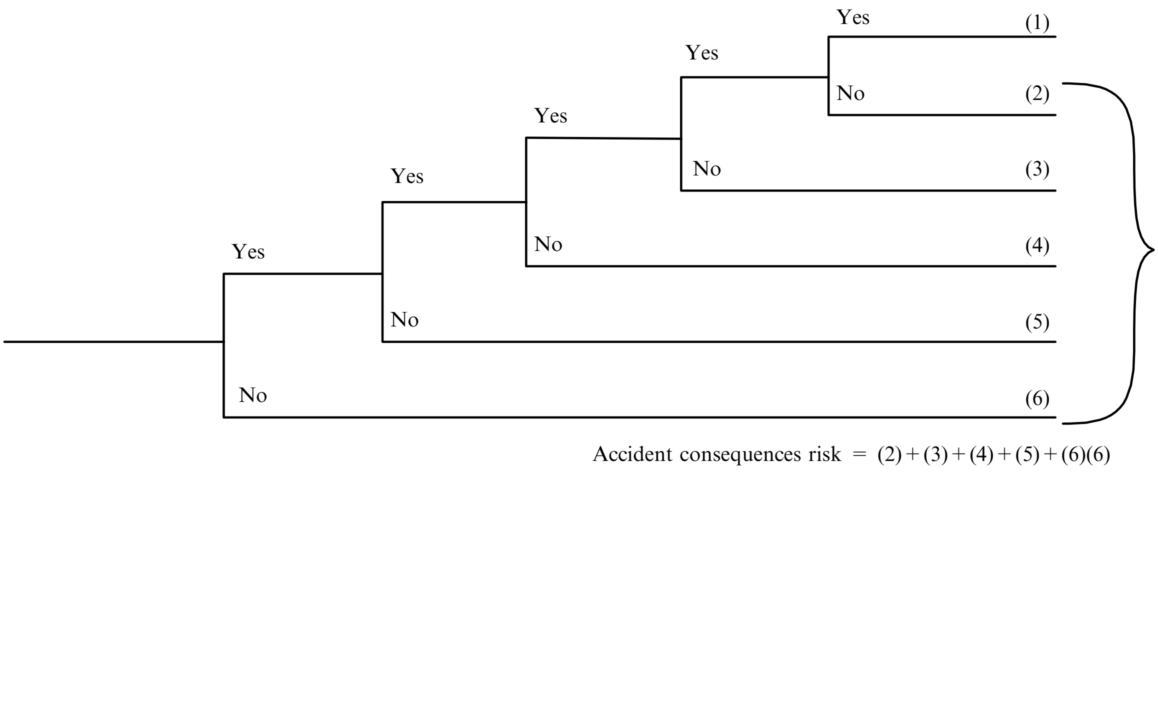
the conditions enabling the most effective work of the team of experts are created, and the team is headed by an experienced analyst who is well aware of the Delphi technique;

all the team members are provided with the information available on the problem in question.

Table 3.3.5

Type event tree for assessment of platform post-damage consequences

Can the given damage be identified as taken into account (as design) in platform hull design?	Did the technical condition of the structure as a whole meet normative documents?	Will the accepted environmental conditions (loads) for a damaged platform be exceeded?	Will it be possible to fail for systems and arrangements like anchor lines, dynamic positioning systems, etc.?	Will the damages of other elements of the platform hull be possible?	Combined probability: Yes — minimum accident consequences, No — accident
consequences risk	1	2	3	4	5



Accident consequences risk = (2) + (3) + (4) + (5) + (6)(6)

The sequence of conditions in use of the Delphi technique is organized as follows:

.1 a leading analyst or someone else on his behalf prepares the initial information on the problem which is presented to the team of selected experts in writing or orally, or in both ways if necessary;

.2 the experts deliver their judgement evaluated either by ranking of versions proposed (if quantitative assessments are impracticable) or by quantitative assessments of the event in question (if possible);

.3 opinions received from the individual experts guided by the analyst are compared and comments of each expert are discussed;

.4 the experts re-evaluate their initial judgements if, from their standpoint, there are prerequisites for this;

.5 the final result of assessment is drawn up.

3.4.2 Coefficient of concordance.

The extent of experts team consent is evaluated using a coefficient of concordance W

$$W = \frac{12 \cdot \sum_{i=1}^{i=n} \left\{ \sum_{j=1}^{j=n} x_{ij} - \frac{1}{2} m \cdot (n+1) \right\}}{m^2 (n^3 - n)} \qquad (3.4.2\text{-}1)$$

where m = number of experts;
n = number of objects.

The coefficient W varies from 0 to 1. $W = 0$ means that no linkage exists between experts rankings, while $W = 1$ means that all experts rank objects for a given attribute in the same way.

The estimate of concordance coefficient significance is defined using a parameter Z

$$Z = \frac{1}{2} \ln \frac{(m-1)W}{1-W} \qquad (3.4.2\text{-}2)$$

which has a Fisher distribution with degrees of freedom

$v_1 = n - 1 - \frac{2}{m}$ and $v_2 = (m-1)v_1$.

A Pearson χ^2 criterion may be used for the quantity $n > 7$. The quantity $m(n-1)W$ has a χ^2 distribution with $v = n - 1$ degrees of freedom.

The tolerable value of the concordance coefficient W is equal to $W = 0{,}5$ at the confidence level of probability equal to 0,995.

3.4.3 Coefficient of pair correlation.

Rank correlation techniques are applied for working problems associated with processing of information having qualitative and comparative nature.

In classifying the qualitative information, the so-called ranking is applied which implies the arrangement of n objects in ascending or descending order of some quantitatively nonmeasurable attribute X. A rank x_i indicates the place that the i-th object occupies among other n objects ranked according to the attribute X.

A coefficient of rank correlation ρ presents statistics of ranked objects linkage. This coefficient evaluates the linkage between qualitative attributes of separate objects, which are not subject to precise quantitative evaluation

$$\rho = 1 - \frac{6S(d^2)}{n(n^2-1)} \qquad (3.4.3\text{-}1)$$

where n = number of objects;

$$S(d^2) = \sum_{i=1}^{n} (x_i - y_i)^2 \qquad (3.4.3\text{-}2)$$

where x_i, y_i = properties in question.

Properties of the coefficient of rank correlation:

$$-1 \leqslant \rho \leqslant +1.$$

$\rho = 0$ means that the attributes X and Y for n objects are independent by ranking these objects for the attribute Y.

$\rho = -1$ means that ranking of objects for the attributes X and Y is fully opposite.

If x_i and y_i are random variables, the coefficient of rank correlation turns into an ordinary coefficient of pair correlation

$$\rho = \frac{\mathrm{cov}(XY)}{\sigma(X) \cdot \sigma(Y)} \qquad (3.4.3\text{-}3)$$

where $\sigma(X)$ and $\sigma(Y)$ = X and Y standard deviations respectively;
cov (XY) = X and Y covariation.

4 RISK CONTROL

4.1 SELECTION OF RISK CONTROL OPTIONS

4.1.1 General.

4.1.1.1 The purpose of risk control is to propose the effective and practical risk control option that comprises three principal stages:

focusing on areas of risk needing control;

identifying potential risk control measures;

grouping risk control measures into practical regulatory options.

4.1.1.2 In the course of materialization of 4.1.1.1, the procedure for selection of the risk control option that is acceptable both for existing traditional accident situations and accident situations caused by new technologies or new methods of operation, is to be created. At the first stage, the classification of the QAR results is carried out so that main efforts are focused on the areas most needing risk control. The main aspects to be reflected therewith are the following:

accidents with an unacceptable risk level become primary focus;

in construction of a fault and event tree, first of all, the risks mostly contributing to the outcome are identified.

4.1.1.3 The selection of a risk control option is above all associated with specific risk control measures. It is recommended a detailed causal chain when the risk control measures are being identified:

hazard → accident situation → accident → consequences.

Risk control measures are to be aimed at:

reducing the frequency of failures through better design, use of up-to-date technologies, organizational policies, training;

mitigating the effect of failures in order to prevent accidents;

alleviating the circumstances in which failures may occur;

mitigating the consequences of accidents.

4.1.1.4 In the course of risk control selection, the relevant measures are to be grouped into a limited number of well thought out practical regulatory options.

Two feasible approaches for group in individual measures are recommended:

"general approach" which provides risk control by the assessment of the accident initiation probability; this approach may be effective in preventing several different accident sequences;

"distributed approach" which provides control of escalation of accidents, together with the possibility of influencing the later stages of escalation of other, perhaps unrelated, accidents.

4.1.1.5 The selected way of risk control is assessed for its effectiveness with regard to risk reduction using techniques specified in Section 3.

As the result of the risk control option selected, the list of arrangements for its materialization is drawn up.

4.1.2 In environmental effects.

4.1.2.1 Selecting the architectonic-constructive type of a platform, the possibility of minimizing external loads applied is to be taken into account in every possible way for which purpose the contemporary methods of analysis of effects and platform responses are used.

4.1.2.2 In consideration of platform safety issues in external effects, all their adverse combinations are to be allowed for. For the platforms fixed on the seabed, safety is to be ensured with due regard for seabed property changes in service.

4.1.2.3 On ecologically critical platforms, inspection and measuring equipment is to be provided to notify the personnel of adverse consequences of external effects. This equipment may incorporate monitoring of the environment and main responses of the platform to severe effects (sea, ice, seismic effects, seabed reactions).

The Register approves the installation of developed systems of inspection and measuring equipment on the new type platforms what provides the possibility of its use in a research mode to accumulate the data on platform behavior in intended and unintended situations.

4.1.3 In collisions with ships and floating objects.

The most efficient and effective means of risk control is the establishment of safety echelons around platforms.

At the design stage, the conception of safety is to be created that includes the three-stage control of risk for which purpose are introduced:

safety echelons around the platform;

effective protection of the hull against a collision;

limitations of damage parameters.

4.1.3.1 Platform safety echelons include two types.

The external echelon (2 to 6 mile-zone around the platform) where limitations on ships speed and routing apply. The extent of limitations depends on:

ship's type, displacement and draught;

ship's manoeuvrability;

ship's equipment (CPP, thrusters, rotary propellers, active positioning systems, etc.).

The limitations on towing of poorly-controlled objects are to be applied within the echelon.

The internal echelon (0,5 to 2 mile-zone around the platform) where strict limitations on ships presence apply; the velocity towards the platform along the zone radius is to be not more than 2 to 4 knots depending on the ship, its displacement, manoeuvring capabilities, systems of ship and platform protection against a collision; any towing of poorly-controlled objects within the echelon is excluded.

The radii of the safety echelons may be corrected by a designer on agreement with the Register and customer depending on the platform type (self-elevating MODU, semi-submersible MODU, FOP and tension leg unit).

For the FOP being also an oil storage, an additional zone of estrangement within $\leqslant 0,5$ miles is established where the presence of any ships and floating objects after completion of their operations with the platform is absolutely forbidden.

Monitoring and prevention of ships traffic and presence in the safety echelons are to be carried out from the platform.

4.1.3.2 The effective structural protection of the platform hull against a collision with ships is to include shock-absorbing and deformation protection of the hull.

The shock-absorbing protection of the platform against ships being moored at sea is ensured with pneumatic fenders or other shock-absorbing means equivalent with respect to energy intensity and a specific contact force.

The platform deformation protection is ensured with structures being crumpled and scattering the impact energy during their deformation, and dampening the contact force down to the value that the deformation protection may take up.

It is allowed to use one type of protection on the platforms and another, on support and transport ships.

The effective structural protection of the platform is to ensure, according to Part II "Hull" of Rules for the Classification and Construction of Sea-Going Ships, the mooring of special purpose ships at sea state up to 6 inclusive.

For the FOP being also an oil storage, a special structural protection as part of a mooring/transfer-at-sea system is needed which is to be agreed with the Register by a designer in an established order. The midpart of the FOP inclined sides span in the area of the ships approach is to be reinforced with vertical stiffeners or inclined stops to avoid deformations of spans due to ship potential crawling over.

4.1.3.3 Where the protection, nevertheless, proved to have been broken through and the platform has received the hull damage, its outside dimensions are not to exceed those confirmed by special calculations.

If the overall dimensions of the damage are exceeded, the Register has a right to make a decision on the increase of the risk level of platform operation and on the necessity of its removal from operation. The permissible parameters of the damage are to be determined according to 4.1.6. In case of leakage, urgent measures on its elimination are to be taken and, where necessary, the package of measures according to Part V "Subdivision" of Rules for the Classification and Construction of Sea-Going Ships, is to be followed.

4.1.4 With explosions, dropping and flying objects.

4.1.4.1 The measures to control the risks associated with explosions, dropping and flying objects and also with the helicopter accident may be integrated into two groups as to their impact on various stages of an accident:

measures affecting the potential source of an accident situation and ensuring the reduction of the probability for accident situation occurrence;

measures affecting accident progress and ensuring the reduction of its consequences.

The first group measures only relate to the sources of explosions and dropping (flying) objects, which are present on the platform.

4.1.4.2 The key measures of the first group are:

conservative approach during design based on the wide use of accumulated positive design experience for safety assurance;

performance of periodical inspections (surveys, etc.) of equipment and other sources of explosions and dropping (flying) objects in the course of operation; the inspections are to be rather frequent to ensure a proper time reserve between the detection of a fault (failure) and the potential destruction;

use of observation systems for sources featuring rather high (close to a maximum for the given type of events) parameters and characteristics of striking factors; an observation technique is to provide for monitoring of certain conditions which may point to failure start; the example of such a system is the system of vibration sensors on large-sized equipment with rotating parts.

The first group measures are also to include the whole package of fire-fighting measures.

4.1.4.3 The key measures of the second group are:

arrangement, grouping and relevant positioning of equipment;

redundancy of systems which can effect on the progress and magnitude of accident consequences;

physical separation of stand-by safety systems;

use of special protective structures (structural protection systems);

use of standard structures (by their special design) as protective barriers;

ensuring of preferable (the least hazardous for the magnitude of consequences) accident progress (propagation of striking factors).

4.1.4.4 In order to ensure the necessary safety level (acceptable risk level), it is usually needed to implement the package of the first and second group measures.

The best is to be considered the approach, which allows to reduce down to an acceptable small value the probability of occurrence of an explosion, flying or dropping objects. The measures of the first group are aimed at it.

The next in preference is the approach ensuring reduction or exclusion of striking factor effects on the object (space, equipment, personnel, etc.), which is essential for safety. And the following is the approach, which ensures the acceptable magnitude of consequences. The second group measures are aimed at handling the last two problems.

4.1.5 In fires and blowouts.

In order to ensure safety in fire on a MODU, the package of fire-fighting measures is to be implemented. It makes sense to divide all these measures into four groups.

4.1.5.1 The first group deals with the measures of organizational character, namely:

development and formal drawing up of instructions for performance of all the works on the MODU;

development of duty regulations for the MODU entire personnel;

strict observance of the standards and requirements of safety regulations during performance of any works on the unit, implementation of an allowance system for conducting all fire-hazardous works;

development and formal drawing up of clear instructions for personnel actions in fire extinguishing;

development and implementation of a training system on the MODU with the check of knowledge obtained by personnel.

4.1.5.2 The second group includes the measures of technical character aimed at prevention of the possibility of fire occurrence on a MODU. The most essential of them are:

application of the explosion-proof and fire-proof equipment, machines, machinery, devices and systems in fire-hazardous areas and spaces of the MODU;

installation on the MODU of a special system preventing oil and (or) gas blowout;

use on the MODU of systems for transfer of combustible liquids in which the possibility of fuel or lubricating oil leakage is kept to a minimum;

maintenance of relevant air composition in MODU spaces by installation of gas-analysing and ventilation systems;

limitations on the use of combustible materials in MODU service, general purpose and accommodation spaces.

4.1.5.3 The measures on passive protection against fire aimed at prevention of its propagation on a MODU (Part VI "Fire Protection" of Rules for the Classification and Construction of Sea-Going Ships) form the third group of fire-fighting measures. In terms of risk control, the following measures among them are to be considered as crucial:

module design of the unit according to a technological principle;

separation of one module from the other, as well as of one fire-hazardous space from another by cofferdams or gastight fire-resistant bulkheads;

implementation of special measures for ensuring safe evacuation of personnel from any service, general purpose or accommodation spaces through passageways, corridors, trunks fitted with fire protection;

arrangement on a MODU of a special space-shelter in which the personnel may be in safety over a certain period of time needed either for fire extinguishing or evacuation of people from the MODU.

4.1.5.4 The fourth group includes active measures on fire fighting. It comprises fire extinguishing systems, which use various physical and chemical principles of operation, namely:

water fire main system;

sprinkler system;

drenching system;

water-screen system;

pressure water-spraying system;

flooding system;

carbon dioxide smothering system;

inert gas system;

foam fire extinguishing system;

dry powder system.

4.1.6 Structural sufficiency.

4.1.6.1 The problems of structural sufficiency control are to be considered during design, construction and operation of offshore platforms, and also during hull structure updating.

Structural sufficiency is ensured through:

structure strength;

structure integrity;

operational reliability;

structure endurance.

4.1.6.2 The main concern in assurance of structural sufficiency is to be with:

special structural elements;

main structural elements essential for assurance of tightness and for safety of platform operating personnel (e.g. such as: helicopter platform structures, a working deck, areas of ships mooring);

main structural elements essential for structure endurance.

4.1.6.3 The measures for control of structural sufficiency (which may be organizational, technical, structural, etc.) are subdivided into traditional, additional and special.

4.1.6.3.1 Traditional control measures are aimed at assurance of structure strength, structural integrity, operational reliability and regulated by the requirements of Part II "Hull" of MODU/FOP Rules, Guidelines on Technical Supervision of MODU in Service, etc. (see 2.1.2).

4.1.6.3.2 Additional control measures are mainly aimed at assurance of structural integrity, operational reliability and associated with the use of non-traditional materials, unique structures and units, non-traditional inspection techniques.

4.1.6.3.3 Special control measures are mainly aimed at assurance of structure endurance and necessarily associated with the evaluation of an accident situations possibility (see 2.1.3).

4.1.6.4 The traditional control measures include:

.1 during design:

calculation of structure strength for given loads in accordance with accepted criteria;

meeting the requirements for minimum thicknesses;

development of special instructions and normative documents on assurance or the operational reliability of a structure (e.g. Instructions for MODU Operation, Methodical Instructions on Assessment of Technical

Condition of the Hull, Recommendations for Underwater Survey, etc.);

examination of strength calculations, other arrangements for assurance of design quality;

.2 during construction:

control of main material quality;

control of structural element joints quality;

control of structure manufacture at large, other measures for assurance of manufacture quality;

.3 during operation:

the periodical survey and inspection for defects of structural elements and their joints including the inspection of the underwater part of a structure using contemporary technical means of underwater examination;

identification of structural elements which do not meet the requirements of the normative documents for assessment of the technical condition of a structure;

repair of structural elements.

4.1.6.5 Additional control measures.

4.1.6.5.1 The additional control measures during design include:

experimental studies of strength and operability of non-traditional hull structures and units;

development of special requirements for engineering of unique structures and units;

experimental studies of non-traditional materials and development of special requirements for them;

development, where necessary, of special normative documents to ensure operational reliability of non-traditional structures, development of special requirements for non-traditional control systems like automated monitoring of environmental parameters, acoustic and emission monitoring of fatigue cracks propagation, monitoring by sample witnesses, etc.

4.1.6.5.2 The additional control measures during construction consist of use of non-traditional materials and monitoring of manufacture quality for structures made thereof.

4.1.6.5.3 The additional control measures during operation consist of use of non-traditional monitoring systems and assurance of their operation quality.

4.1.6.6 The special control measures are developed in the course of design and implemented during platforms construction and operation.

4.1.6.6.1 On the whole the adequate protection against an accident damage is achieved by two ways:

low damage probability;

tolerable damage consequences.

The special control measures are mainly aimed at the tolerable damage consequences.

4.1.6.6.2 The control measures for assurance of structure endurance include:

structural measures in order to withstand the effects of accident events or to reduce to a minimum their consequences;

organizational measures for accident rate reduction like the development of special accident plans and arrangements with regard to the minimization of the risk of a collision with ships, icebergs and of other accident events;

the measures of technical character associated, for instance, with the use of systems and devices for monitoring machinery whose damage may result in the destruction of the platform hull (e.g. such a mechanism is the jacking system of a self-elevating MODU).

4.1.6.6.3 Structural redundancy is of vital importance for assurance of structure endurance. A structural system is to be so selected that its carrying structure and the most essential elements retain integrity in the course of and immediately after an accident while other structural elements therewith may be damaged. Following the damage, the structure is to withstand minimum functional and environmental loads during the certain period of time up to platform removal from operation.

4.1.6.6.4 The Register may require the calculations and other motivations based on an engineering approach which validate that the strength of the hull with a damaged element will be ensured, i.e. the damage of a certain strength member (members) will not cause platform hull destruction.

This problem is to be worked out with due regard for:

design conditions of a damage (damaged elements, other parameters) are to be established to fit a particular offshore platform in terms of accident situations and structural features of a structure under consideration;

where the special instructions in the relevant parts of MODU/FOP Rules and other normative documents of the Register are unavailable, as design loads are to be used functional loads due to the platform, cargo and equipment weight only (i.e. it is assumed that machinery, systems and arrangements may be inactive), and also environmental loads corresponding to the largest during a year for the operational area in question;

an ultimate strength criterion is to be assumed as a strength criterion according to the formula

$$\Phi \leqslant R \tag{4.1.6.6.4}$$

where Φ = design value of a generalized force effect;
R = design value of a generalized carrying capacity (design structure resistance);

calculation methods may be based on the plastic analysis of structural elements behaviour.

4.1.6.7 The above provisions on structural sufficiency control are to be perceived as the minimum requirements of a general nature on which basis the individual requirements to fit the offshore platform of the particular type are to be determined with due regard for the assessment of an accident situations possibility.

4.1.6.8 The control measures on structural sufficiency will be more convincing if available data in respect of platform structure damages due to accident events are used. Accumulation of such data is to be conducted in form of Appendix 4.

4.2 COST BENEFIT ASSESSMENT ASSOCIATED WITH MEASURES ON RISK REDUCTION

4.2.1 The purpose of this step is to identify benefits and costs associated with the implementation of each risk control option identified and defined in 4.1.

4.2.2 A cost benefit assessment consists of the following stages:

consider the risks assessed in Section 3, both in terms of frequency and consequences, in order to define the base cause in terms of risk levels of the situation under consideration;

arrange the risk control options, defined in 4.1, in a way to facilitate understanding of the costs and benefits resulting from the adoption of one or other option;

estimate the pertinent costs and benefits for all risk control options;

estimate and compare the cost effectiveness of each option in terms of the relative cost per unit risk reduction;

rank the risk control options from a cost-benefit perspective in order to facilitate the decision making recommendations in the next step (e.g. to screen those which are not cost effective or impractical).

4.2.3 Costs are to cover the entire life cycle and may include an initial cycle, operation, training, inspection, certification, etc. Benefits may include reductions in the costs associated with fatalities, injuries, casualties, losses environmental damage, indemnity of third party liabilities, and an increase in the average life of the structure.

The evaluation of the above costs and benefits can be carried out by using various methods and techniques. Such a process is to be conducted for the overall situation in order to identify the main effects.

A cost is determined in relation to the person, organization, company, coastal zone management, etc. who is directly or indirectly affected by an accident. In this step, the effectiveness of the new proposals is determined. In the initial stage of a formal safety assessment (FSA), the basic risk directions are to be grouped together for the purposes of applying the FSA methodology and identifying decision making recommendations.

As the result are assessed:

costs and benefits for each risk control option identified in 4.1;

costs and benefits for the measures which are the most influential on the result;

cost effectiveness expressed in terms of net cost per unit risk reduction.

4.2.4 The cost effectiveness of the measure selected is recommended to determine working a probability-optimization problem either on the basis of minimization of a *P*-type effectiveness function

$$P = S + p\bar{u} \qquad (4.2.4\text{-}1)$$

or on the basis of the method of increments

$$I = S\Delta - \bar{u}\delta p \qquad (4.2.4\text{-}2)$$

where I = measure benefit;
S = initial cost of the structure, equipment, platform;
$\bar{u}$ = probability average loss in case of a failure;
p = probability of a failure (risk value) referred to the entire life time of the structure, equipment, platform.
Δ and = relevant increments.

5 CRITERIA OF PLATFORMS SUFFICIENT SAFETY

5.1 RECOMMENDATIONS FOR DECISION MAKING ON ACCIDENT RISK REDUCTION

5.1.1 The purpose of this step is to define the recommendations on the reduction of an accident risk. The recommendations are to be based on the comparison and ranking of hazards and their underlying causes, on the comparison of risk control options and to be followed in order to reduce the risk down to the most reasonable level.

Output from these actions is to provide an objective comparison of alternative options, based on the potential reduction of a risk level and cost effectiveness of risk control options, including areas where standards and rules are to be reviewed or supplemented. The recommendations are to be correlated in various contexts with the IMO recommendations and not to contradict the IACS approaches.

This step is the most important in the entire chain of FSA actions and is to be thoroughly considered.

5.1.2 All the decisions made for accident risk reduction are to meet the effective Rules of the Register and operational standards specified inappropriate operating instructions approved by the Register in order to ensure platform safety.

Operational standards are used everywhere during the platform entire life cycle. It is vital that they be related to the systems and processes, which facilitate the reduction of a total risk, the number of the operational standards therewith is to facilitate the better safety management.

The operational standards are related to a particular platform and they are recommended to be formed at three levels:

risk-based operational standards which specify the quantitative parameters to be met (see 5.3);

operational scenario standards which may be qualitative or quantitative specifying a final purpose for management when a specific hazard or group of hazards occur;

operational system standards which specify the level of activity or competence that is needed from the system called for management when a hazard occurs.

5.2 AS LOW AS REASONABLY PRACTICABLE PRINCIPLE

5.2.1 The identification of hazards and analysis of consequences of their materialization allow even in the first step to define some, even though, preliminary priority of hazards. For this purpose a risk matrix is used according to which all hazards are distributed over three levels: intolerable, as low as reasonably practicable, and tolerable.

Intolerable hazards are those in respect of which the risk can not be justified except in extraordinary circumstances. Among such hazards are the ones whose materialization probability has an ordinary average level, but consequences are catastrophic.

Tolerable hazards are those whose materialization is remote, and the consequences are insignificant. In respect of such hazards, no precautions are needed and they may be excluded from further consideration.

The regulation of tolerable and intolerable values of risks is given in 5.3. The ALARP (as low as reasonably practicable) level falls between the "tolerable" and "intolerable" levels.

The base risk matrix is illustrated in Fig. 5.2. The materialization of the risk matrix is carried out according to the identification of specific potential risks. Following the definition of an objective, the team (group) of experts performing the examination within the framework of a FSA methodology is formed. The work is recommended to be conducted in three phases: preparation, identification of risks, processing and documenting.

Where risk cannot be quantified, the qualitative qualification of accident circumstances is allowed using the following definitions for accident magnitude categories and the accident probability according to Tables 5.2-1 and 5.2-2. The qualitative qualification allows to complete the risk matrix in which the levels 1 and 7 present the highest and the lowest risks, respectively. The ALARP zone is consistent with three to five levels.

FREQUENCY				
Frequent	level 4	level 3	Level 2	unacceptable level 1
Reasonably probable	level 5	ALARP level 4	Level 3	level 2
Remote	level 6	level 5	Level 4	level 3
extremely remote	acceptable level 7	level 6	Level 5	level 4
	insignificant	minor	major	catastrophic
				CONSEQUENCES

Fig. 5.2 Risk matrix
ALARP = as low as reasonably practicable

Table 5.2-1

Accident magnitude (consequences)

Insignificant	No significant damage to people, equipment and the environment
Minor	Insignificant reduction in platform performance, local damages
Major	Significant reduction in platform performance accompanied with serious injuries
Catastrophic	Platform loss or ecological catastrophe

Table 5.2-2

Accident probability

Extremely remote	Only likely to happen in exceptional cases
Remote	Unlikely, but not unknown, to happen during the life cycle of a platform
Reasonably probable	Likely to happen during the life cycle of a platform
Frequent	Likely to happen yearly or more frequently

5.3 NEGLIGIBLE AND UNACCEPTABLE RISK LEVELS

5.3.1 As safety criteria for annual individual risks are to be accepted:

unacceptable risk level = 10^{-3} per year;
negligible risk level = 10^{-6} per year.

The range between 10^{-3} per year and 10^{-6} per year is the ALARP region.

APPENDIX 1

GENERAL RECOMMENDATIONS FOR DRAWING UP AND USING OF A CHECKLIST OF SELF-ELEVATING MODU 6500/100 JACKING SYSTEM

I. BRIEF TECHNICAL DESCRIPTION OF SELF-ELEVATING MODU 6500/100 JACKING SYSTEM

The self-elevating mobile offshore drilling unit SPBU 6500/100 "Murmanskaya" has three trihedral gridwork legs and is intended for exploration drilling of wells up to 6500 m deep in water depths in a drilling position from 20 m to 100 m at the air temperature within -30 °C to $+40$ °C. A wind force 6 and sea state up to 5 during the platform transit are assumed as acceptable.

Main technical characteristics:

light displacement afloat abt. 15000 t;

length (design) abt. 88,2 m;

breadth (design) abt. 68,0 m;

depth abt. 9,7 m;

draught (light) abt. 5,3 m;

length of the trihedral gridwork leg abt. 143 m.

The jacking system with a rack-and-pinion mechanism, operating by a step-by-step principle, is installed on the self-elevating MODU. It consists of three jacks mounted on a jack house at each leg corner and of a moving yoke, which encloses the leg, with three racks connected to it by means of articulated joints. The jack includes three twin reduction gears with two output gear wheels, electric motors and brakes.

The catching gear being part of the jack mechanism includes three catches (one at each corner of the leg) located on the yoke and three catches similarly arranged at the lower part of the jack house. The catch pins are driven (slid in and out of the special openings in the nodal joints of vertical corner struts of the legs) with pneumatic drives.

The work cycle of the jack consists of two operations:

working run — elevation (lowering) of the pontoon (leg);

idle run — rearrangement of the yoke for one step downwards or upwards.

The lower catches activate in the end of the working run joining the pontoon and leg. Following the full load transfer to the lower catches, the upper ones set the yoke free for rearrangement, i.e. movement of the yoke with racks for one step till the activation of the upper catches. The lower catches set the leg free and the next working run follows.

In order to reduce stresses and deformations of the vertical strut, the technological lugs in its cast nodal joints are provided to ensure transmission of transverse loads in the nodes of a leg grid only. The similar contact supports ("skis") are fitted in the hull of the self-elevating MODU in three pieces at each vertical strut. The protruding nodes of the vertical struts slide along them in platform rearrangement and rest on them in operation.

II. GENERAL RECOMMENDATIONS FOR DRAWING UP AND USING OF THE CHECKLIST OF AN ACCIDENT SITUATION ANALYSIS AS APPLIED TO THE JACKING SYSTEM OF A SELF-ELEVATING MODU

1. Introductory part

The checklist of an accident situation analysis in the platform areas with an average and high risk level helps to identify mistakes in a design and a potential threat to safety using the list of questions intended for the encouragement of thinking and a discussion process.

The questions in the checklist usually deal with those areas where there were mistakes in a design or in operation. The significant part of the questions is the outcome of the examination of the problems identified in previous reviews or as the result of accidents. The checklist does not concern, as a rule, the areas where designers rarely make mistakes. The checklist is to be used only for the thorough and comprehensive review of a design, but not as a design technique for the unit or its separate areas.

2. Pertinent information

The procedure for use of the checklist demands knowledge of the sound background of the design, equipment layout, safety and fire protection systems, operational technology, etc. The package of documents is to be stored during the entire life cycle of the unit as the basis for future modifications and the accident situation analysis.

3. Methods

In order to perform the analysis of accident situations, a team is formed which includes the representatives of a design organization, operators and at least one experiences specialist not directly involved in unit's design or operation. The analysis may be conducted both by one specialist and by small groups, each in its discipline.

To facilitate a review, the checklist is usually divided into some sections, and in doing so, as applied to the

Table

Analysis (review) subject	Contents	Documentation in aid of
1. General	A. General matters B. Layout C. Response to an extreme situation D. Evacuation and salvaging	Design background Drawings of general arrangement and equipment layout
2. Mechanical part	A. Structural materials B. Jacking system for legs C. Elevation mechanism D. System for legs embedding into seabed and for their pulling out E. Piping	Specification for materials, equipment, arrangements Drawings Patents Technological procedures for the elevation/lowering of legs and for their embedding into seabed, etc.
3. Electrical part and control system	A. Electrical classification of zones B. Diagram of electric circuits laying	Specification for electrical equipment and devices, drawings Specification for pipes and valves

jacking system of the self-elevating MODU, in the following sections (see column 1 of the Table).

The checklist does not contain the requirements for answering each question with "yes" or "no". Experts are to use the checklist questions as the lines of thinking and identification of potential problems.

The checklist questions are not necessarily the "requirements of design safety". In many cases, they confer a right on questioning participants for selection. It may be expected that the review and analysis of accident situations according to the checklist on even an existing platform will turn into the larger number of undesirable answers than the review of a new design, as an additional risk in terms of safety is associated with a need to update the actually existing unit.

4. Report

The analysis is to be documented so that it may be identified who and when conducted it, which information was examined and the subsequent recommendations. The hazards identified and recommendations obtained as the result of answers for questions are reasonably to present as a master table, which is like the one whose form, is given in the end of the present Appendix. Each item is to have references to an appropriate question of the checklist used for problem identification. These items are based on the team's assessments and discussions with the platform designers and operators. Such items are to be introduced for only those platform areas whose condition causes alarm.

III. EXAMPLE OF THE CHECKLIST OF SELF-ELEVATING MODU 6500/100 JACKING SYSTEM[1]

1. General

1.A. General matters.

1.A.1. Are hazards properly addressed?

Is the method of their elimination and control thought out?

1.A.2. Which new processes and equipment, systems and arrangements are used on the unit what may demand the more thorough analysis of safety (e.g. HAZOP)?

1.A.3. Has the operability of the jacking system been taken into account in the design? (Complicated systems will most likely be operated with violations and interlocks will later be switched off.).

1.A.4. Have the requirements for safety systems testing been defined? Does the design meet these requirements?

1.A.5. Have all hazardous materials been examined and classed?

Have the certificates for materials been examined?

Have the measures for personnel's protection been developed?

1.B. Layout.

1.B.1. Are accommodation spaces, the deck house and control stations properly arranged in order to reduce contacts with the equipment and arrangements of a higher hazard?

1.B.2. Has provision been made for installation of additional equipment that may interfere with the safe operation?

1.B.3. Has the arrangement and separation of equipment and appliances between the jack house and yoke been thought out?

1.C. Response to an extreme situation.

1.C.1. Is provision made for accommodation of personnel in emergence of an extreme situation?

1.C.2. Are communications or means of communication with ships or a shore available?

1.D. Evacuation and salvaging.

1.D.1. Is the number of seats in life-saving appliances, lifeboats and liferafts sufficient for accommodation of 100 per cent of the operating personnel including the attached one?

1.D.2. Is the platform provided with life-saving appliances to expand escape routes?

[1]Questions of the checklist are subdivided into groups according to the recommendation of II.3 of the present Annex.

1.D.3. Is the use of lifelines as evacuation means, when the other means are ineffective, thought out?

2. Mechanical part

2.A. Structural materials.

2.A.1. Is the selection of structural materials correct and the use of non-ferrous metals instead of a ferrous metal justified?

2.A.2. Is the combination of materials consistent with the safety requirements being effective for the sea fleet?

2.A.3. Are the zones for drainage of exhausted materials and corrosion products thought out and are there obstacles for their natural disposal?

2.A.4. Are additional technological reinforcements, including the material of welds, preventing the proper operation lacking?

2.B. Jacking system for legs.

2.B.1. Does the jacking system for legs make possible the operation with the essentially different subsidence of legs in soft soils?

2.B.2. Is provision made for a reliable interlock in the system when the upper and lower levels of the catching gear operate?

2.B.3. Does the jacking system take into account the accident catching of the leg?

2.C. Elevation mechanism.

2.C.1. Are provisions made for maintenance platforms, passageways and guards in the design of elevation mechanism arrangement according to the safety requirements being effective in the sea fleet?

2.C.2. Is the safe operation of the elevation mechanism and reduction gear ensured at the design level with the ingress of corrosion and sea activity products into them?

2.C.3. Can the elevation mechanism damage (destroy) the permutable rack, the output pinion of the reduction gear etc. while operating with the pins of the upper and lower belts secured on the leg?

2.C.4. Is the safe operation of the mechanism with the permutable pinion assessed during design?

2.C.5. Are provisions made for the testbed trials of the elevation mechanism and for the assessment of its reliability in terms of potential accident situations?

2.C.6. Are there limitations on wind, waves and other conditions for the jacking system during the transit of the self-elevating MODU?

2.D. System for legs embedding into seabed and for their pulling out.

2.D.1. Is the resource of the system sufficient for the withdrawal of an accident leg from seabed?

2.D.2. Is the plan of system operation with the leg cocked in the jack house during leg pulling out/embedding thought out?

2.D.3. Is provision made for a mechanism to accommodate excess displacements due to the cocking of the leg during lowering/elevation?

2.D.4. Is the system fitted with the effective subsystem for washing and taking a soil off the legs, which ensures system safe operation during pulling out/embedding?

2.E. Piping.

2.E.1. Are the safety and cut-off valves of the pneumatic drives of the jacking system protected against damage and do they have an adequate resource?

2.E.2. Are provisions made for piping pressure test and blow-through?

3. Electrical part and control system

3.A. Electrical classification of zones.

3.A.1. Is the break-down of electrical equipment, cable networks and the control system into electrical zones consistent with existing state standards?

3.A.2. Is provision made for the emergency switching-off of electric motors of reduction gears at the following accident situations:

electric motors overheating;

yoke displacement outside the limits of a working run;

excess of a catching period;

excess compression of shock-absorbers;

excess of the permissible total current of jack motors?

3.A.3. Are all the accident situations associated with jack motors considered?

3.B. Diagram of electric circuits laying.

3.B.1. Does the existing diagram of cable laying allow to ensure safety of control system circuits from an accidental pulse?

3.B.2. Is provision made for protective earthing against an electric and static shock according to the rules, which are effective in the sea fleet?

3.B.3. Is duplication ensured for the electric circuits of the control and alarm systems of the jacking system?

3.B.4. Is the protection of jacking system control circuits against a human factor available?

IV. FORM OF MASTER TABLE FOR REPORT ON ACCIDENT SITUATIONS ANALYSIS

Platform ______________________ Executed ______________________ Date __________

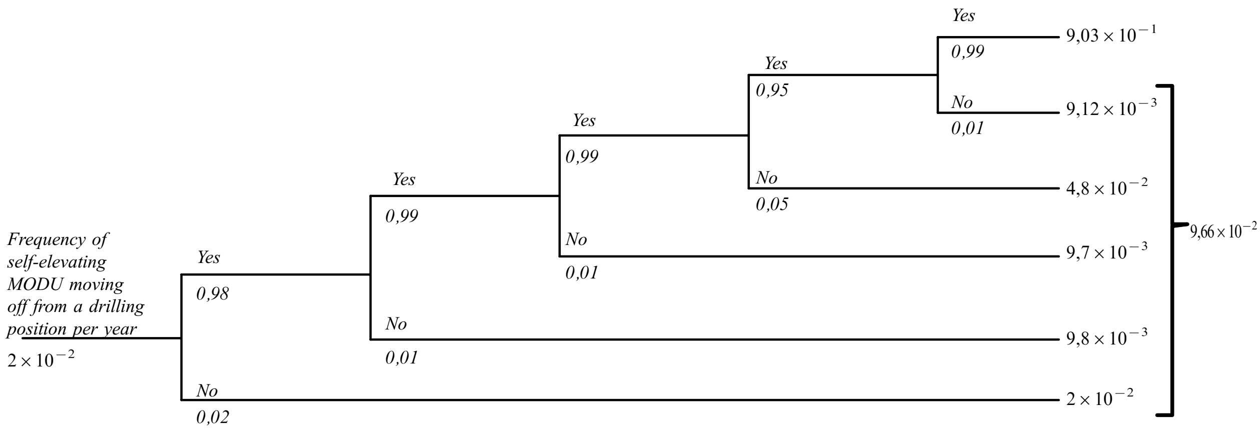
No. of checklist	No. of drawing	Problem	Discussion	Recommendations	Signature	Date

APPENDIX 2

EXAMPLES OF EVENT TREES

Table 1 Event tree during pulling out the legs of a self-elevating MODU from seabed

Will the weather remain within the limits accepted in the operating instruction? 1	Will the extent of footing sticking to seabed be within acceptable limits? 2	Will there be unacceptable heeling angles? 3	Will operability of machinery remain intact? 4	Will legs crawling off and, in this connection, elevation mechanism jamming occur? 5	Combined probability: Yes = accident will not occur No = accident risk

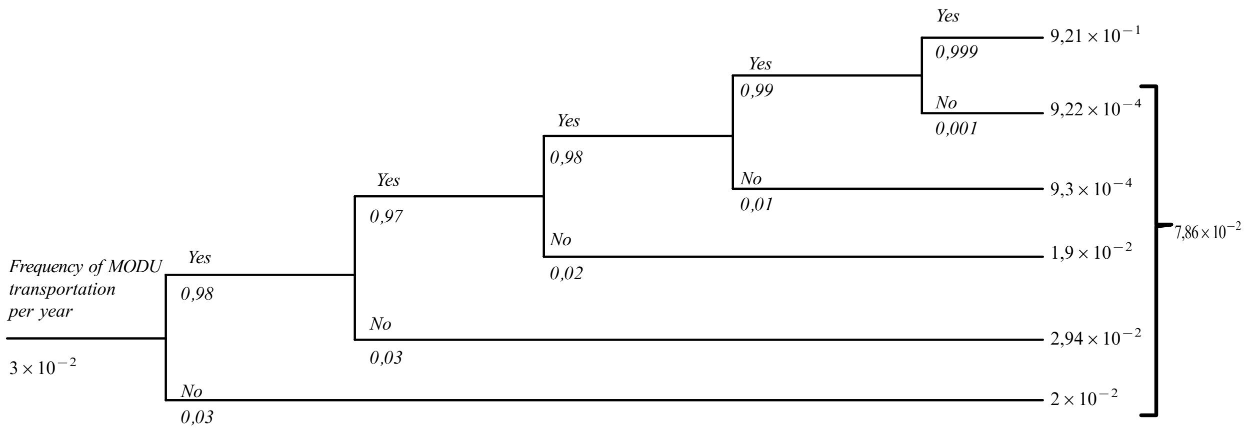


Check sum **1,0**

Accident risk $9{,}66 \times 10^{-2}$

Table 2 Event tree during transportation of self-elevating and semi-submersible MODU

Will the weather remain within the limits accepted in the operating instruction? 1	Will there be mistakes in a weather forecast in an adverse way? 2	Are there organizational and technical obstacles for implementation of the operating instruction? 3	Is the operating instruction properly used (human factor)? 4	Can the elevation machinery fail? 5	Combined probability: Yes = accident will not occur No = accident risk

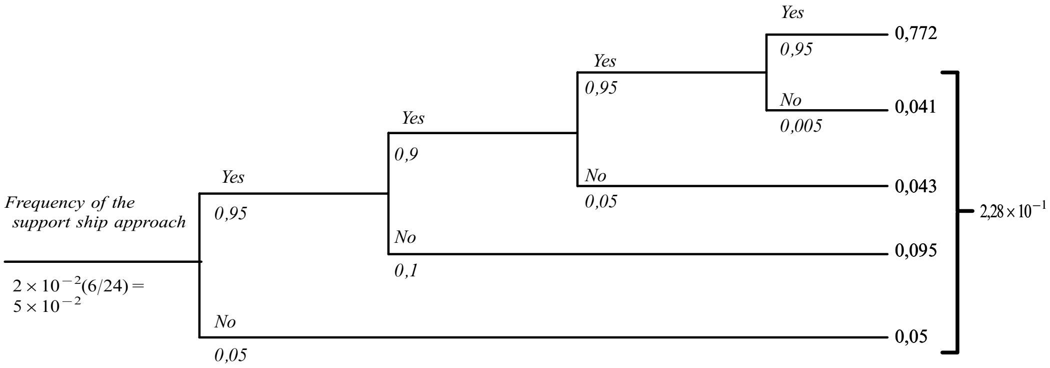


Check sum **1,0**

Accident risk $7{,}86 \times 10^{-2}$

Table 3 Event tree in running aboard a self-elevating unit

Will the ship remain within the limits of an intended situation in relation to the self-elevating MODU? 1	Validity of weather conditions forecast: is the weather situation consistent with the forecast? 2	Will the lifeline be broken? 3	Will the ship's power plant be fully serviceable? 4	Combined probability: Yes = accident will not occur No = accident risk

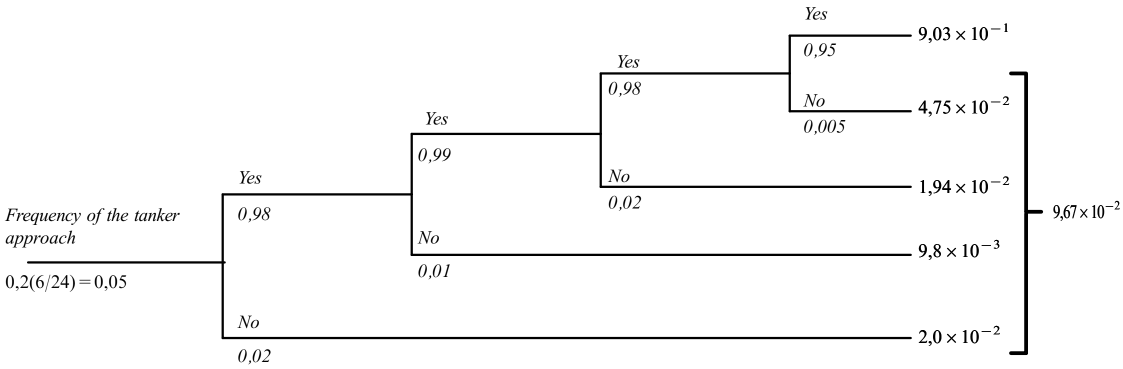


Check sum **1,0**

Accident risk $2{,}28 \times 10^{-1}$

Table 4 Event tree in collision of a tanker with a fixed platform

Is machinery serviceable and are speed conditions observed? 1	Is the tanker rudder healthy? 2	Is the thruster healthy? 3	Are damping ice conditions favourable? 4	Combined probability: Yes = accident will not occur No = accident risk

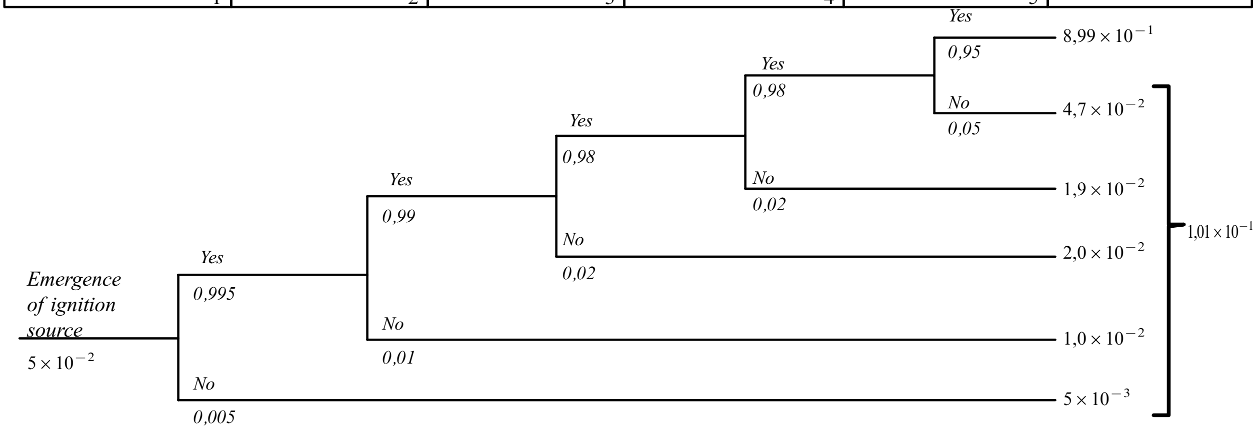


Check sum **1,0**

Accident risk $9{,}67 \times 10^{-2}$

Table 5 Event tree in fire in internal spaces of a MODU

Will the measures aimed at prevention of ignition be implemented? 1	Will the moment of a fire beginning be detected? 2	Will there be mistakes in carrying out measures on fire extinguishing? 3	Will the measures on fire extinguishing be effective? 4	Will the fire result in appreciable structure damage? 5	Combined probability: Yes = accident will not occur No = accident risk

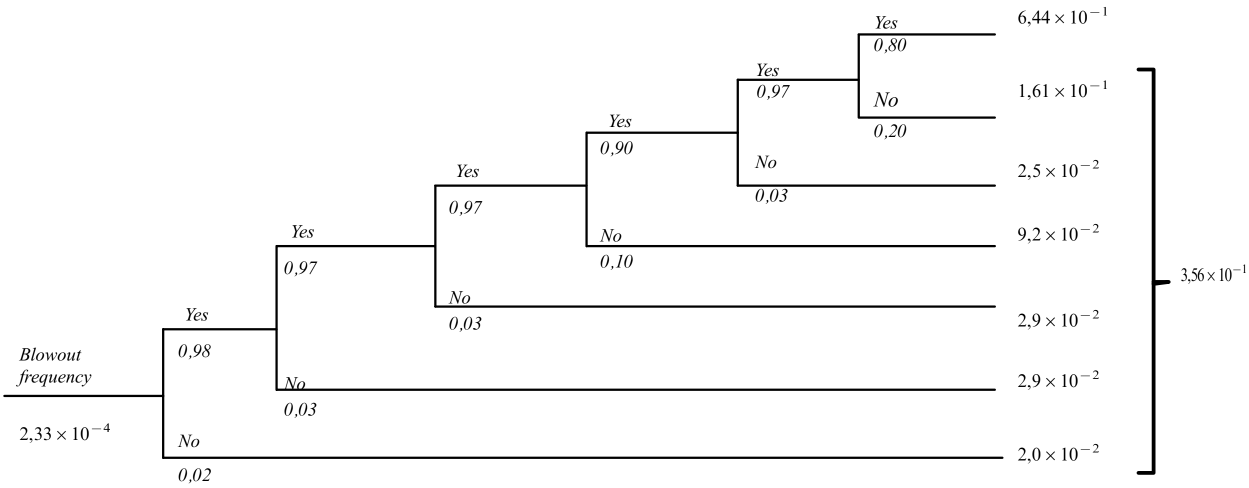


Check sum **1,0**

Accident risk $1,01 \times 10^{-1}$

Table 6 Event tree in blowout fire aboard a platform

Will the measures taken to prevent blowout ignition be effective? 1	Will standard fire extinguishing systems be rendered operational? 2	Will the use of standard fire extinguishing systems be effective? 3	Will the use of additional fire extinguishing means be needed? 4	Do ice conditions or sea state allow using additional fire extinguishing means? 5	Will the fire result in essential damages to the platform? 6	Combined probability: Yes = accident will not occur No = accident risk

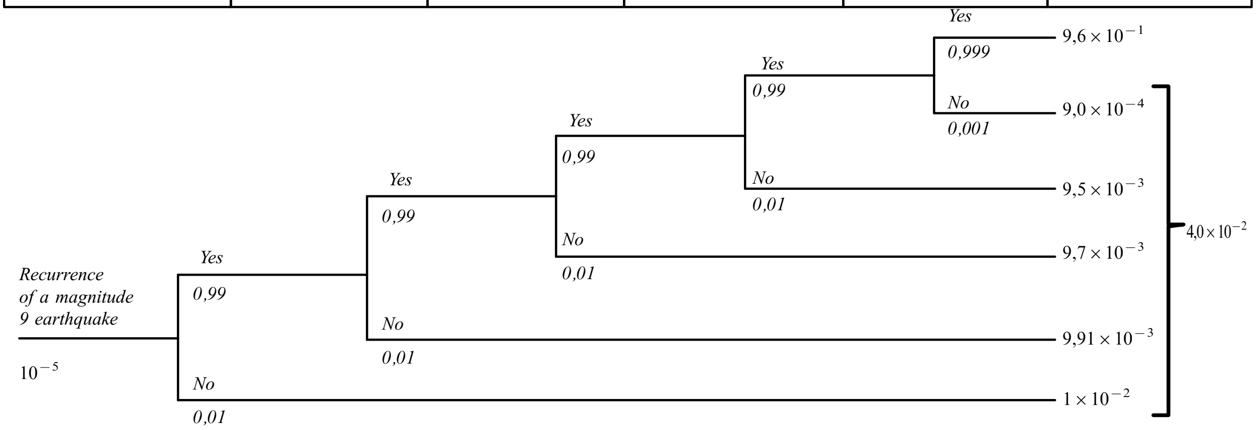


Check sum **1,0**

Accident risk $3,56 \times 10^{-1}$

Table 7 Event tree in seismic effects on a platform

Will the duration of an earthquake be within design limits? 1	Will soil properties remain within acceptable limits? 2	Will the shift (angle of rotation) of a unit for a value exceeding the design one happen? 3	Will the break of structure integrity exceed the design one? 4	Will an accident accompanied by oil product laakages, explosions, fires, casualties happen? 5	Combined probability: Yes = accident will not occur No = accident rick

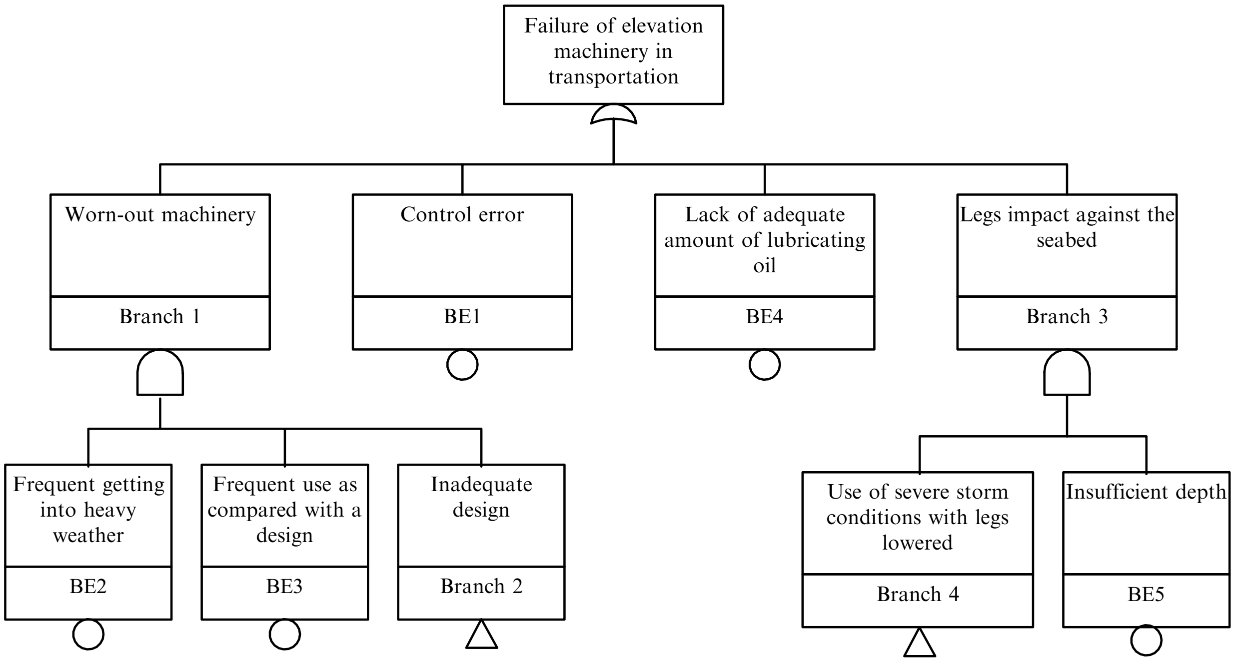


Check sum **1,0**

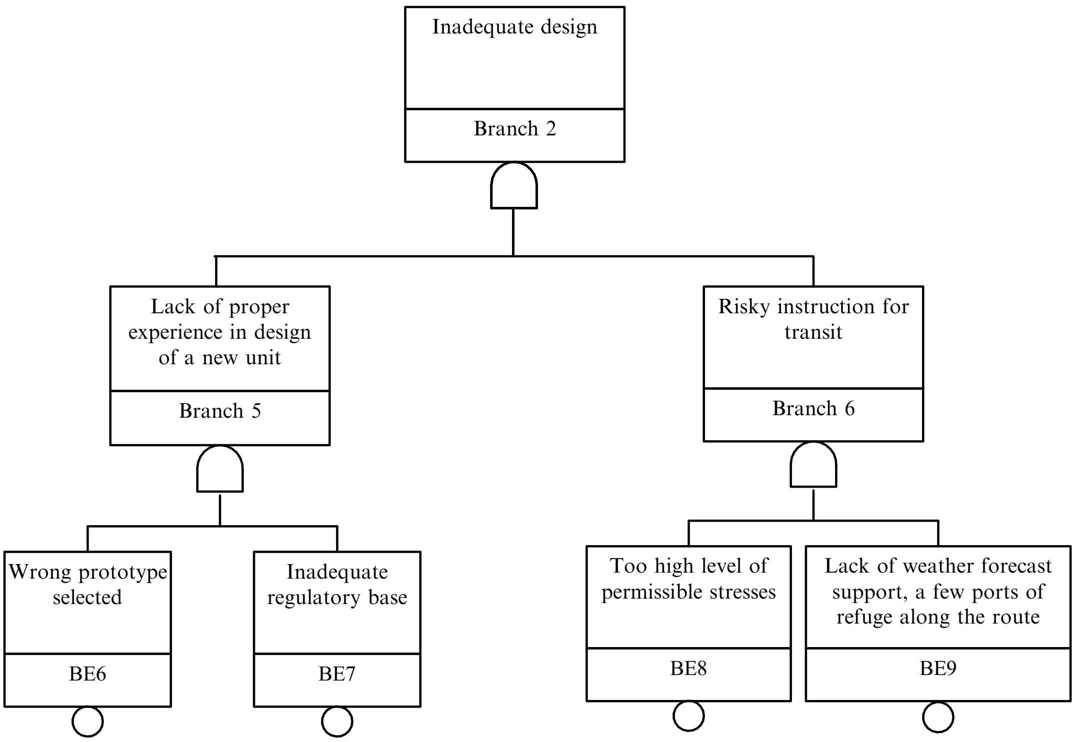
Accident risk $4{,}0 \times 10^{-2}$

APPENDIX 3

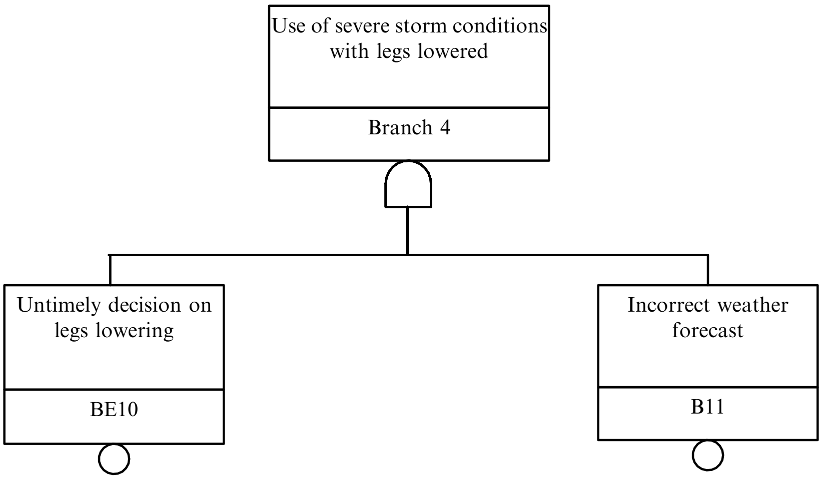
EXAMPLES OF ERROR AND FAULT TREES



Initial construction of an error and fault tree

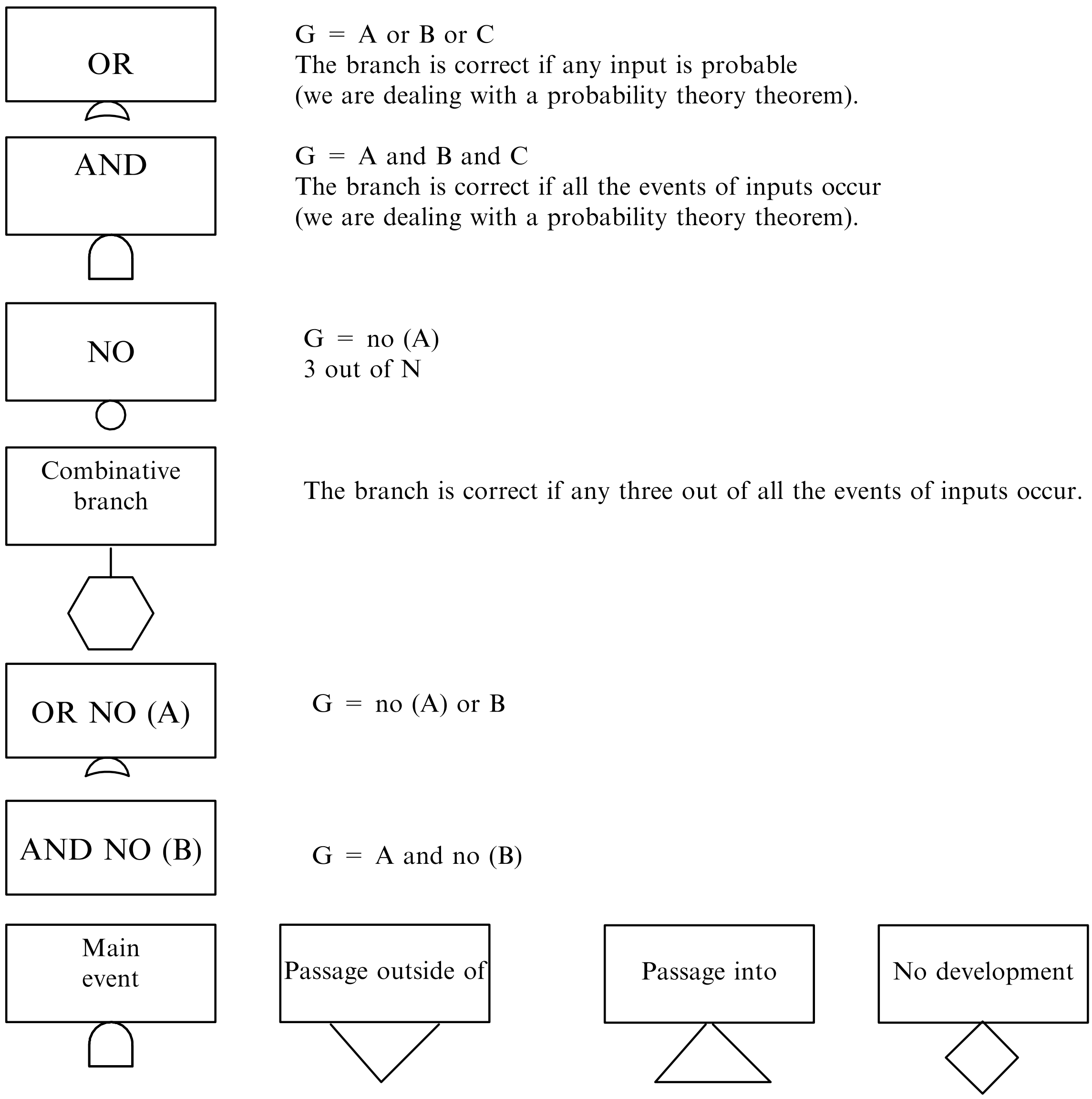


Continuation of error and fault tree construction



Continuation of error and fault tree construction

G branch symbols



APPENDIX 4

CONSTUCTION OF *FN* CURVES

The *FN* curves relate to societal risk, not to individual. The societal risk testifies a catastrophe magnitude.

E x a m p l e . Assume that the case in point is 10 fatalities on 5 platforms of the same type. These 10 fatalities could happen both on 5 platforms with two victims on each and on one platform where 10 people would die at once. For the hypothetical example of 10 fatalities under consideration, the following distribution is assumed (Table 1).

T a b l e 1

Statistics of fatalities on platforms of one type

Platform	I	II	III	IV	V
Number of the dead (*N*)	2	1	1	4	2

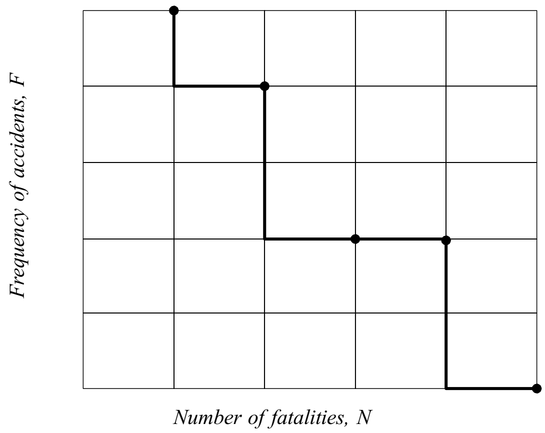
The same data in Table 2 are presented in the form more suitable for the further analysis. The Table 2 data allow to construct a graph with the horizontal axis *N* — "Number of fatalities", and the vertical axis *F* — "Frequency of accidents" in which at least *N* people have died (Fig. 1).

T a b l e 2

Frequency of fatalities and their distribution

Number of the dead *N*	Number of accidents in which *N* people have died	Frequency of accidents (number of cases per platform) in which *N* people have died	Number of accidents in which at least *N* people have died	Frequency of accidents (number of cases per platform) in which at least *N* people
1	2	2/50 = 0,04	5	5/50 = 0,1
2	2	2/50 = 0,04	3	3/50 = 0,06
3	0	0/50 = 0	1	1/50 = 0,02
4	1	1,50 = 0,02	1	1/50 = 0,02
5	0	0,50 = 0	0	0/50 = 0

The plots or the type in question are called *FN* diagrams. The societal risk is the integral characteristic of the consequences of certain kind hazards materialization.



Frequency of fatalities on platforms on which at least *N* people have died

APPENDIX 5

FORM OF PRESENTATION OF INFORMATION ON DAMAGES OF OFFSHORE PLATFORM STRUCTURES OBTAINED IN ACCIDENT AND INCTRUCTION FOR ITS FILLING

FORM OF PRESENTATION OF INFORMATION ON DAMAGES OF OFFSHORE PLATFORMS STRUCTURES

Section 1. General type of an offshore platform	
Section 2. Design number	
Section 3. Distinctive attributes of a specific structure	
3.1 Registered number	
3.2 Name of the structure	
3.3 Date built (updated)	
Section 4. Distinctive attributes of the organization that has presented information	
4.1 Name of the organization (Register Branch Office)	
4.2 Date of information presentation	
Section 5. General data about the object (description of a structure, material, draught, sea depth in a drilling position, etc.)	
Section 6. General description of an accident event and damages	
6.1 General diagram of a structure	
6.2 Damage types	
6.3 Date of an accident and its consequences	
6.4 Operational conditions when damages have happened	
6.5 Description of environmental conditions (if data are available)	
6.6 Platform position when damages have happened	
6.7 Probable causes of damages occurrence	
6.8 List of damaged structural elements	
6.9 General condition of the offshore platform after damage	
6.10 Water area pollution	
6.11 Casualties	
6.12 Other data	
Section 7. Description of damages (to be presented: the diagram of a damaged structural element, strength member dimensions required, damage dimensions, accompanying information, etc.); the number of pages is not regulated.	

INSTRUCTION FOR FILLING THE FORM

Section 1. General type of an offshore platform.

The following designations are used:

semi-submersible MODU = semi-submersible mobile offshore drilling unit;

self-elevating MODU = self-elevating mobile offshore drilling unit;

FOP = fixed offshore platform.

Section 2. Design number.

No explanations are needed.

Section 3. Distinctive attributes of a specific structure.

No explanations are needed.

Section 4. Distinctive attributes of the organization that has presented the information.

No explanations are needed.

Section 5. General data about the object.

Structural particulars are presented:

list of hull components (hull structures);

their names, design and number (e.g. self-elevating MODU legs of the truss type — 4 pcs.);

main dimensions of the hull at large and characteristic dimensions of hull structures;

for FOP, the architectonic-constructive type (e.g. platform on legs, monopode, etc.), the way of keeping on the seabed.

The materials, of which platform structures are mainly fabricated, are to be specified.

The draught for various operation conditions is to be specified for mobile units, and the sea depth in a drilling position for FOP and self-elevating MODU.

In addition, the particulars of a clearance, ice strake and other features of a platform may be provided.

Section 6. General description of an accident event and damages.

6.1 General diagram of the structure.

To be stated whether the diagram is presented in Appendix to Form or not. The diagram is usually presented when the object is new, non-traditional or in other cases if necessary in the opinion of the organization completing the Form. The diagram may be presented as a three-dimensional sketch, in some projections showing damaged elements and areas, with numbering of structural elements, etc. for the better description of the structure and damages.

If the diagram is of no need in the opinion of the organization completing the Form, it may be lacking.

6.2 Damage types.

The following types are specified:

residual deformations;

break of integrity (cracks, ruptures, fractures);

other types due to platform structural features.

All the types of damages corresponding to a specific accident event are to be listed.

6.3 Date of the accident and its consequences.

No explanations are needed.

6.4 Operational conditions when damages have happened.

One of the following modes is specified:

transportation;

positioning on location;

operating conditions;

survival or extreme loading;

moving off from location;

any other design mode of operation due to specific nature of a structure.

6.5 Description of environmental conditions (if data are available).

Data on the wave height, wind velocity, ice formations, seismic situation, air temperature, etc. are presented.

6.6 Platform position when damages have happened.

An operational area and a sailing route are at least to be specified.

6.7 Probable causes of damages occurrence.

The causes like the following may be specified:

extreme hydrometeorological conditions;

earthquakes;

collisions with ships and other floating objects;

dropped objects;

helicopter accident;

explosions;

fires;

blowouts;

seabed fluidization;

structure shifting or capsizing;

accumulation of fatigue damages;

mistakes in design and manufacture of a structure;

violation of the operating instruction requirements;

combination or the sequential chain of the above events resulting in damages;

other causes attributed to the specific nature of a structure.

6.8 List of structural elements damaged.

All damaged structural elements omitting the details of damaged areas are to be listed. For example, as applied to a self-elevating MODU:

leg elements, joints of a pontoon with an outrigger, helicopter deck elements, etc.;

to a semi-submersible MODU:

support girders of the upper hull, horizontal bracings, stability columns, pontoons in way of a sheer strake, etc.

The description is to be rather general as the detailed description of damages will be given in Section 7.

6.9 General condition of the offshore platform after damage.

The following is to be specified:

the platform has remained in operation without repair up to planned arrangements;

the repair has been carried out without platform removal from service;

the platform has been removed from service for repair, utilization, etc.

The clause may be supplemented with other items.

6.10 Water area pollution.

To be, at least, indicated: Yes or No.

6.11 Casualties.

No explanations are needed.

6.12 Other data, which are essential in the opinion of inspection services and the platform owner.

Section 7. Description of damages.

The description is to be brief, clear and, as far as possible, informative.

In this Section, it is to be detailed the damaged areas and damage types, presented the diagrams of damaged structural elements (where needed, in a certain order with reference to 6.1), the dimensions (parameters) of damages, the necessary dimensions of structural elements; repair techniques and other appropriate information may be detailed as well.

All that attendant information, which is essential in the opinion of the organization completing the Form, is to be presented.

There is a good reason to highlight in some way the damage parameters in the text.

PART XVI. MARINE OPERATIONS

1 BASIC PRINCIPLES, CRITERIA AND REQUIREMENTS FOR DEVELOPMENT AND PERFORMANCE OF MARINE OPERATIONS

1.1 APPLICATION

1.1.1 The requirements of this Part apply to technological marine operations carried out in the construction and operation of marine drilling and producing structures which (or their parts) have buoyancy of their own and are covered by the supervision of the Register.

1.1.2 The concepts of planning and performance of marine operations not regulated by this Part are separately to be considered and approved by the Register in each particular case. In this case, the information and documentation which allow to ascertain the efficiency and safety level of performance of all the operations in question are to be submitted to the Register.

1.1.3 The provisions of this Part establish the appropriate necessary amount of technical documentation while planning marine operations. Where necessary, the Register may demand increasing the amount of documentation to be submitted.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 For the purpose of the present Part the following definitions have been adopted.

Block is a self-floating element of the platform support foundation.

Module is the element of the platform upper structure.

Tier is the aggregate of horizontally joined blocks.

Column is the vertically oriented not of necessity self-floating block.

Assembly means any combination of the elements of the unfinished platform.

Support deck is a load-carrying deck for the upper structure modules, which rests upon the support foundation.

Technological buoyancy pontoon (tower) is a watertight tank being temporarily attached to the structure to ensure its buoyancy and stability during a marine operation.

Technological construction operations afloat means the operations for assembly, transportation, joining and installation at the location of the structure or its parts (blocks, tiers, columns, modules, positioning systems, etc.), carried out when the structure or any of its parts are in floating condition. Two types of operations are recognized:

Shipyard operations afloat are space-limited operations afloat conducted at an outfitting quay (pier) or within a fully protected shipyard water area.

Marine operations are space-unlimited operations afloat conducted within a semi-protected water area or on high seas.

Launching is the dynamic operation of the floating up of an assembly, block or module in a dry dock, or after sliding from the slip or down the skid beams on the barge.

Mating by floating is the vertical mating of tiers or elements of the column or support foundation with the upper structure wherein the lower element submerges, but the upper element to be mated is floated over it and the whole assembly emerges.

Capsizing means the turn of a floating structure by 90° by means of the relevant ballasting.

Transportation is a marine operation during construction of the structure (platform), which includes all the operations associated with the transport of the platform at large or its separate large-sized elements from a construction site (shipyard) till the location of the next marine operation, final in-place installation inclusive.

Towing means transportation of a self-floating structure or its part.

Short-time towing means the towing weather-restricted by the time interval of the forecast of the good weather "window" (not more than 3 days).

Prolonged towing means the towing unrestricted by weather or time.

Ballasting is loading or emptying of ballast tanks or compartments.

Positioning means the marine operation necessary to manoeuvre and keep the platform properly oriented and precisely located over a predetermined point of seabed.

Stay is the marine operation stage performed for temporary keeping the platform afloat with constant coordinates.

Installation is the marine operation, which includes the procedures for submergence and positioning of the platform at a working location, and its setting in accordance with the design.

Recognized standards, guidance documents, methods of calculation and design are operating national, industrial, departmental norms and standards, GOSTs, OSTs, guidance documents, and also the calculation methods developed by separate organizations and authors, foreign ones inclusive, approved by the Register.

Planning (design) of the marine operation means substantiation of all the technological procedures and support means (arrangements, fixtures, devices, machinery, tugs, etc.) necessary for their execution, which permit to safely reach the set objective effectively, and at the minimum cost.

1.3 BASIC PRINCIPLES OF MARINE OPERATION PLANNING

1.3.1 Marine operations are to be designed (planned) and performed regarding safety conditions and in accordance with the provisions of this Part, operating standards and guidance documents.

1.3.2 Marine operation planning is to take into account potential emergency situations. When the emergency situation occurs, the platform is to remain stable and under control.

1.3.3 Planning of marine operations is to provide the possibility of their performance under safe conditions or of their suspension when environmental design parameters are exceeded and other emergency situations occur. If the operation enters the phase when it can not be suspended or terminated, such phases are subject to special consideration in the design and safe conditions for them are to be determined.

1.3.4 The design of marine operations is to be based, as a rule, on approved principles, technology, systems and equipment. All potential accidental situations are to be reviewed during the design of marine operations and the relevant plans of arrangements are to be developed. Such plans are to include the list of additional spare (consumable) equipment on board the platform and support ships, the activities of support personnel, the description of procedures for hazard prevention, etc. The safe conditions of marine operation performance provide for the prevention of:

losses and the emergence of hazard for platform structures, ships and other objects involved in the operation;

the threat to the personnel's life and health;

pollution and other environmental accidents.

1.3.5 All marine operations in question are to be planned, executed and monitored in accordance with a specially developed design and by the qualified and competent personnel having the necessary experience and good technical training evidenced by appropriate certificates and licenses.

1.3.6 The actual conditions of particular marine operation performance are not to be substantially different from the conditions set in the relevant operations design.

1.3.7 The design, organization and performance of marine operations are to be carried out in accordance with the provisions of this Part, and also with the recognized standards, guidance documents, calculation and design methods, as well as, where necessary, with the foreign standards approved by the Register. MODU/FOP Rules do not forbid the use of other more effective calculation methods and technical approaches provided they ensure the necessary safety level set by the Rules. All additional standards and methods used are to be submitted to the Register for consideration and approval.

1.3.8 When marine operations are planned and designed, the following work sequence is recommended:

review and generalization of the requirements, rules and regulations, standards relating to the marine operation under consideration;

review and generalization of environmental conditions;

general planning of the operation including establishing of the basic principles of operation performance, equipment needed, economic factors, etc.;

definition of environmental conditions and restrictions acceptable for operation performance;

brief description of actions in operation performance;

execution of calculations and engineering developments;

development of a works performance design.

1.3.9 The composition of input data and output documentation is to be determined at early stages of design. The definition of environmental conditions and limitations, as well as design briefs are to ensure a general basis for the design of the marine operation, and also to give a clear insight into all the stages of marine operation performance and monitoring. The description of environmental conditions is to include basic parameters, characteristic conditions, design loads and reactions, load combinations, etc. The design briefs are to contain planned and controlled actions, design and calculation methods used, initial specifications, accepted criteria, etc.

1.3.10 The following documentation on the marine operation design is to be submitted to the Register: general explanatory note, drawings, strength calculations, work performance descriptions, test programs, certificates for equipment used, documents confirming personnel's qualification, etc. The Register representatives are to be provided with the possibility of being present during the most essential tests, equipment and structural components inspections to confirm the compliance of their parameters with the developed design, and also during the performance of the marine operation at large or its particular stages to evaluate the conformity of permissible environmental conditions for the beginning and execution of the operation.

1.4 CATEGORIES OF MARINE OPERATIONS DEPENDING ON THEIR DURATION AND WEATHER CONDITIONS

1.4.1 This Part only covers technological operations afloat, i.e. shipyard and marine operations conducted for offshore platforms or their separate parts. These operations include:

launching of blocks or columns;

outfitting, assembly and horizontal mating of blocks afloat;

vertical mating of tiers by floating;

vertical mating of the support foundation and upper structure by floating;

towing (prolonged or short-time) of the support foundation or platform;

installation of the platform at a working position.

1.4.2 Planning and design of marine operations is to be based on an estimated operation time T_{est} defined as:

$$T_{est} = T_p + T_o \tag{1.4.2}$$

where T_p = planned (design) operation time;
T_o = overrun of the planned operation time due to casual natural or technical factors.

If the overrun of the planned operation time T_o due to casual factors is not known, it may be assumed equal to the planned operation time T_p, but not less than 6 h.

1.4.3 Depending on the estimated duration, marine operations are subdivided into:

weather-unrestricted operations with a duration over 72 h;

weather-restricted operations with a duration under 72 h.

The operations with a duration over 72 h may be considered as weather-restricted if the operation may be suspended during its execution and the platform may be moved into a sheltered position when acceptable criteria and weather conditions are exceeded. Marine operations with the estimated duration under 12 h are considered separately.

1.4.4 For weather-restricted operations, design environmental conditions may be assumed irrespective of statistical data for the operation area, i.e. to be established in each specific case in the request for design coming from the structural features of a platform, technical capabilities of support ships available, etc. The start of such operations is conditional upon acceptable weather conditions and their favourable forecast.

1.4.5 Regarding instability of weather conditions and inexactness of weather forecasts, the acceptable criteria of weather conditions for the actual beginning and the performance of a marine operation are to be assumed less the design criteria adopted. The acceptable criteria of weather conditions C_o for marine operation performance are determined by the formula

$$C_o \leqslant \alpha C_D \tag{1.4.5}$$

where C_D = design criteria of weather conditions;
α = reducing factor taken equal to:
0,8 for an average (anemometric) wind velocity;
see Table 1.4.5 for wave heights.

Table 1.4.5

Reducing factor α for sea

Estimated operation time T_{est}, hours	Design height of wave with 3% probability of exceeding level, m		
	$1 < h_{3\%} \leqslant 2$	$2 < h_{3\%} \leqslant 4$	$h_{3\%} > 4$
< 12	0,52	0,58	0,61
< 24	0,48	0,54	0,57
< 48	0,43	0,49	0,51
< 72	0,39	0,45	0,48

1.4.6 For marine operations with the duration over 72 h, but which may be classified as weather-restricted, when acceptable design weather conditions are established, the total duration of all separate stages is to be taken into account. The acceptable criteria of weather conditions C_o for such operations are separately set in each particular case.

1.4.7 Environmental conditions for weather-unrestricted marine operations (duration over 72 h) are assumed proceeding from statistical data on extreme conditions for a particular operation area. The acceptable criteria of weather conditions C_o for operations performance may be taken equal to the design criteria.

1.5 ULTIMATE STATES IN MARINE OPERATIONS

1.5.1 The performance of a marine operation on transportation, positioning or installation of a platform is unsafe or prohibitive if efforts in the platform structure, its securing system, towing line or the displacements of the platform and support ships reach the relevant ultimate states.

Conducting a marine operation, the following kinds of the dangerous states of structures, arrangements and equipment of the platform and support ships are to be prevented:

excessive material deformation;

loss of structure shape stability;

formation of fatigue cracks;

brittle failures;

breakages of ropes, chains and other connecting elements.

1.5.2 As ultimate states during performance of marine operations are considered:

the first (basic) ultimate state corresponding to the formation of breaking forces in the structure of a platform, in its securing system, anchor, mooring arrangements and bumpers, and also of the impermissible displacements of the platform and support ships which, if exceeded, may cause their failure or prevent marine operation performance;

the second (operational) ultimate state corresponding to the formation of permissible forces and displacements in the structure and securing system, which, if exceeded, do not cause any damages, or grave disruptions of normal conditions of the marine operation, but testify that normal operational conditions are overpassed;

emergency ultimate state corresponding to the damage (destruction) of one (any) among the main (load-carrying) components of a structure or its securing system.

When needed, due to a prolonged marine operation and provided that the number of design loadings in the operation may reach or exceed several thousand, the fatigue ultimate state wherein the breaking forces corresponding to the first (basic) ultimate state are determined with due regard to fatigue conditions in the structural components of the platform (securing system) taking into account cyclic loads are additionally considered.

1.5.3 When a marine operation is designed, all the above-mentioned ultimate states excepting the fatigue one allowed for when needed are considered.

It is necessary to observe the conditions, which prevent the onset of the ultimate states in question and are specified in 2.4, Part II "Hull" of MODU/FOP Rules.

1.6 ENVIRONMENTAL CONDITIONS, WEATHER FORECAST, INVESTIGATIONS

1.6.1 For marine operations, the design recurrence of external effects is established in each particular case proceeding from the operation duration taking into account the operation area, a year season and the potential consequences of exceeding the assumed design parameters of the effects.

1.6.2 For the marine operations or their separate stages of a short-time duration (up to 72 h) which are weather-independent, the design values of external effects may be assumed proceeding from actual technical capabilities of ships and equipment in use taking into account a specific weather forecast.

1.6.3 Establishing design environmental conditions, their seasonal variations are taken into account. The design parameters are to be assumed with due regard to the specific time of the year wherein the performance of a marine operation is planned. The local environmental conditions, not reflected by generalized statistical data, are to be taken into account, namely:

tide variations,

wave and wind conditions,

current variations.

Pilots, harbour regulations etc. may be sources for such information.

1.6.4 Description, parameters and external effects calculation methods are given in 2.2, Part II "Hull" of MODU/FOP Rules.

1.6.5 Developing the design of a marine operation all environmental conditions affecting its performance are subject to consideration. Conditions of general importance are wind, waves and currents. It is necessary to consider ice, tide variations, temperature, visibility, precipitation, fog and other dangerous meteorological phenomena, as well as hydrographic (bottom contour, sea depth, water area dimensions) and geological conditions at the place of platform installation. When needed, it may also be considered seismic effects during platform installation (until it is secured in a designed position).

The parameters of external conditions are to be assumed for the immediate areas of marine operations performance.

1.6.6 Design parameters of environmental conditions are to be adopted on the basis of generally recognized and reliable observed data of the sufficient duration, and of investigations relating to the area in question. Data over 3 to 4 year period as a minimum are to be used. If the data for a specific area are unavailable, the environmental conditions parameters may be established on the basis of calculations according to the methods recognized in Hydrometeoslujba. The information on collection and origin of environmental conditions data is to be submitted to the Register for consideration and approval.

1.6.7 In order to describe environmental conditions, the generally accepted parameters used in determination of external effects, loads and structure reactions are to be applied. Describing external effects of casual character, long and short-term statistical data are to be used. Special emphasis is to be placed on the assessment of reliability of statistical techniques used and their results. The long-term (condition) functions of variation of such environmental conditions as wind, waves, currents, etc. are largely to be described by certain statistical distributions. Evaluating extreme values of external effect parameters, the recognized extrapolation techniques may be used.

1.6.8 Design parameters of environmental conditions, statistical distributions of their values and directions adopted in the design of marine operations are to be submitted to the Register for consideration and approval.

1.6.9 The scope and composition of investigations in areas of marine operations associated with the essential change of a structure draught (mating by floating, capsizing, platform installation) are adopted in accordance with the type, dimensions, platform importance and available information on environmental, including geological, hydrographic, and other conditions in areas under consideration. The selection of techniques and the range of investigations are to be compatible with environmental conditions of the area in question. Selecting the range of investigations, it is to be taken into account:

mistakes in positioning of floating means used for investigations;

mistakes of navigation equipment used in marine operation performance;

potential deviations of the platform during performance of marine operations under actual conditions.

1.6.10 The results of investigations are to be submitted to the Register for consideration. Such reports are to include:

information on the time of investigation performance and on the performer (organization);

comprehensive description of the equipment used and of the procedure of field and laboratory studies performance;

investigation results;

evaluation of errors and restrictions in application of investigation results.

1.6.11 The topographic survey of seabed is to be conducted for all the kinds of marine operations but a prolonged towing. Sounding accuracy at the platform installation area is to be within $\pm 0{,}1$ m. For other types of marine operations (towing, etc.), the sounding accuracy is determined in each particular case of marine operation performance. Special emphasis is to be placed on potential seabed movements. Additionally to generally accepted sounding techniques, it is recommended scanning the seabed with a multibeam echosounder or other similar device in areas of potential underwater hazards (boulders, anchors, rock fragments, etc.).

1.6.12 Geological investigations are largely conducted for the area of platform immediate installation, and also for the locations of platform anchorage (stay) along a towing route. The scope and composition of geological investigations at the platform installation position may be determined on the bases of the materials of the platform general design as its amount of information is more than adequate for marine operations performance. Particular attention is to be given to geological conditions needed for evaluation of the holding capacity of ship anchors and the anchors of roads facilities during platform stay and positioning. The results of detailed geological investigations may also be needed while handling the problems of platform installation, in particular, for setting up the platform on seabed.

1.6.13 The marine operation design is to include arrangements for receiving weather forecasts prior to and in the course of the operation. The forecasts are to be based on reliable sources and to take into account both actual environmental conditions of the marine operation performance area and the operation duration. The weather forecast is to be recorded.

Additionally to the general description of environmental conditions and their assumed development, the weather forecast is to include:

the wind velocity and direction;

the height, mean and maximum period and direction of wind and long-period waves;

rain, snow, illumination, ice, etc.;

data on sea level variations (tide, storm surge, etc.);

visibility;

temperature;

barometric pressure.

The listed parameters are to be predicted for the period of 12, 24, 48 and 72 h. The forecast for several days is also to be provided.

Special emphasis in weather forecasts is to be placed on the accuracy and reliability of determination of such predictable parameters as an average wind velocity, wave parameters (height and period).

The forecast is to take into account the worst scenario of weather conditions development. This is of prime importance for areas of unsteady weather and for forecasts of poor reliability. The weather forecast may be regarded as favourable for the start of a marine operation if all the above listed parameters do not exceed acceptable criteria.

1.6.14 Depending on the extent to which the performance of different kinds of marine operations is affected by weather conditions, it is recommended to discern three levels of weather prediction: A, B and C.

Level A covers the marine operations most sensitive to weather conditions. Among these are mating of a support foundation with a platform upper structure, sea prolonged towing under heavy environmental conditions, positioning and installation of the platform.

Level B covers the operations dependent on weather conditions the violation of which may result in significant financial losses. Among these are the launching on high seas, weather-restricted short time towing, etc.

Level C covers the operations less sensitive to weather conditions and the operations conducted on a regular basis. Among these are shipyard operations, i.e. mating of blocks, towing in sheltered waters and others.

1.6.15 Weather forecasts depending on the prediction level are to meet the requirements of Table 1.6.15.

1.6.16 External conditions like wind, wind and long-period waves, currents, tide, etc. are to be monitored in the course of a marine operation. Monitoring is to be conducted on a regular basis. The list of parameters under control and inspection methods are to be specified in the operation design. There is a good reason during monitoring to forecast the variation of the controlled parameters in the course of the marine operation. Any unforeseen monitoring results are to be recorded without delay and taken into account in the course of the operation.

Table 1.6.15

Weather prediction levels

Weather prediction level	Is availability of environmental conditions data for the operation performance area needed?	Number of independent sources on which weather forecast is based	Maximum interval of weather forecast, hours
A	Yes	2	12[1]
B	No[2]	2[3]	12
C	No	1	12

[1]Smaller intervals may be considered for the operations most sensitive to weather conditions.
[2]The need for hydrometeorological data for the specific operation performance area is considered and determined separately in each particular case.
[3]When properly justified, the weather forecast may be based on one source only.

Tidal variations are to be monitored with due regard for the period of operation performance and the relevant lunar phase.

1.7 DESIGN, ORGANIZATION AND RESPONSIBILITY FOR MARINE OPERATIONS. DOCUMENTATION, SUPERVISION, TESTING

1.7.1 Marine operations are to be conducted in accordance with the design developed as the part of the platform general design or with the independent design approved by the Register, and also with due regard for good seamanship that prevents unnecessary risks. The responsibility for observance of necessary conditions, rules and requirements of the marine operation performance design rests with the operation manager.

1.7.2 The operation design is to provide the detailed description and the procedure of operation performance, ships and craft involved, structures, arrangements and equipment. All essential aspects of the operation both for normal conditions of its performance and for potential critical situations are to be considered in the design. The design is generally to include, as a minimum, the following sections:

organization and charts of each operation stage performance;

navigation support and communication;

description of external conditions and effects;

restrictions due to external conditions;

restrictions due to strength and stability of the platform and the means and structures in use;

regulations for work performance in marine operation execution;

calculations of resistance and strength for separate components validating reliability, duration and reality of operation performance;

descriptions (drawings and specifications) of structures, assemblies and components.

1.7.3 In the course of any marine operation execution, supervision and monitoring of the operation performance is to be carried out, of platform behavior, separate units and machinery functioning, etc. inclusive. The results of supervision are to be recorded. If the Register-approved design conditions of operations execution are violated, the causes of deviations are to be reviewed, an appropriate conclusion is to be made and the measures taken on their elimination are to be recorded.

1.7.4 The designs of marine operations on platform towing, positioning and installation are to be developed and submitted to the Register for consideration and approval at the set time prior to the beginning of operations.

1.7.5 The designs of marine operations are to be kept at the platform owner and developer. In addition to the designs, the platform owner is to keep the reports and minutes of operation performance supervision. The listed documents are to be submitted to the Register if requested.

1.7.6 The Register supervision is effected to ensure the compliance of the design and conditions of discussed operations execution with MODU/FOP Rules. The Register supervision includes:

approval of the marine operation design;

monitoring in the course of the operation under consideration.

The Register supervision is conducted as an addition to, but not instead of monitoring over the performance of marine operations on the side of a designer, performer and the platform owner.

When it is needed, inspection of marine operations execution conditions (determination of displacements, efforts, environmental conditions parameters, etc.) is conducted using measuring equipment.

1.7.7 In the course of supervision the Register checks:

conformity of structure and arrangements dimensions, and of used materials to the approved design;

performance of arrangements tests prior to the start of the operation;

execution of marine operations in accordance with the design.

1.7.8 Prior to the performance of a marine operation it is to be described in detail the performance organization and established personal responsibility of key personnel involved in the marine operation, extreme and emergency situations inclusive. The design of operation performance is to include an organization chart with names and precise functional duties of key personnel.

1.7.9 Key personnel, as well as supervisors, control organizations and specialists involved in a marine operation are to posses a thorough knowledge and experience within their area of responsibility.

1.7.10 Particular emphasis is to be placed on ensuring reliable communication in organization of a marine operation. Communication lines, primary and secondary means of communication are to be clearly defined in the special section of a marine operation design. The planned flow of information, a common language, etc, are to be presented in the design.

1.7.11 For operations with a planned duration over 12 h the work of personnel is to be arranged in several shifts and the personnel relevant number and composition are to be provided.

1.7.12 All structures, equipment, systems, instrumentation used during a marine operation are to be inspected, calibrated and tested. Tests are to confirm their serviceability and compliance with design specifications, functional requirements and purposes, and characteristics. Both primary and secondary structures, equipment, systems, units and components are to be tested.

1.7.13 As the part of the marine operation design, inspection and test programs, instrumentation calibration procedures in particular, are to be developed. The results of inspections and tests are to be documented. For complicated operations it is recommended to develop the common test program, which specifies the composition, sequence and procedure of inspections and tests for separate structures, equipment and systems. The program is to indicate controlled parameters, characteristics and their values in accordance with the design requirements.

1.7.14 For operations with complex communication/reporting systems and for the most important systems, the preliminary instructing and training of personnel under conditions similar to those which are expected during the actual operation, are to be provided. A key personnel involved in the operation is to be familiarized in detail with the procedure of the operation in the part of their concern. The representatives of supervising and control organizations are to be familiarized with all the aspects of the planned operation and posses an adequate information with respect to limitations and assumptions of the design. A thorough briefing for the representatives of supervising and control organizations regarding responsibilities, communication, work procedures, safety, etc. is to be performed. Other personnel participating in the operation is to be briefed, generally about the operation and specially about safety, survivability, assigned tasks and responsibilities.

1.7.15 The very execution of a marine operation is to be conducted according to the operation performance regulations developed in the design and specifying design external conditions, physical limitations, design provisions, etc. Generally, such regulations are to include:

organization matters;

communication routines and systems;

general equipment;

operational procedures and plan of execution;

peculiarities of operation execution in accidental and extreme dangerous situations;

permissible load conditions for structures, equipment, arrangements, units and components;

criteria of environmental conditions permissible for operation execution;

permissible draughts, trim, heel and corresponding ballasting plan;

platform positioning systems and equipment;

operating instructions for systems and equipment;

support ships;

tow routes and ports of refuge;

navigation support;

hydrometeorological support;

life-saving appliances;

documents receipt/delivery routine;

individual units and components;

forms of documents and reports for recording operation preparation and execution;

plans of arrangements and equipment tests and rejection.

1.7.16 Special emphasis in regulations for operation execution is to be placed on the limitations of conditions of the operation or parts thereof performance.

The documentation developed is to include the full descriptions of all procedures, equipment in use, etc or contain references to well-known available materials containing necessary descriptions. The amount and details of the documentation are to ensure the independent presentation and review of drawings, procedure descriptions and calculations for all operation stages.

1.7.17 Prior to the beginning of design works, the following documentation is to be generalized and submitted:

rules in force;

norms;

tactical and technical requirements;

standards and codes;

concept description;

main engineering characteristics;

contract or its part for design development.

1.7.18 Output documentation is generally to include:

brief descriptions and basic provisions of design, lists, conceptual assessments, general arrangement drawings and specifications;

loads analysis, overall strength evaluation, local strength and ballasting calculations, drawings of structures, units and components;

works performance design, which includes test programs and procedures, operation plans and procedures, safety requirements, appropriate drawings, administrative procedures;

certificates, results (reports) of tests, checks, fabrication, etc.

1.7.19 Execution of marine operations is to be recorded in the log book. The samples of relevant protocol forms are to be included into the operation execution regulations.

1.7.20 The documentation is to contain the well-known characteristics of all structures, components and equipment, of the platform ones inclusive, of temporary and permanent structures, support ships and craft, etc.

The design is to include certificates and classification documents for all the equipment and ships involved in the operation.

1.7.21 The analysis of structure functioning during an operation is to include several levels from the general analysis of operation execution at large till the analysis of individual units and components functioning. Different analysis techniques may be used at different levels.

1.7.22 The design of works performance is recommended to develop as the description of appropriate procedures, operations performance regulations, calculations, etc. The requirements for personnel qualification are to be laid down. All necessary documentation is to be available at any stage of operation execution.

2 REQUIREMENTS FOR BUOYANCY AND STABILITY OF PLATFORM, STRUCTURE AND THEIR COMPONENTS DURING MARINE OPERATIONS

2.1 GENERAL REQUIREMENTS FOR BUOYANCY AND STABILITY

2.1.1 General.

2.1.1.1 Sufficient buoyancy and stability are to be ensured for any floating components of the structure and the whole platform at large in all stages of marine operations. Both intact and damage stability is to be defined and specified for all floating objects and ships in all stages of marine operation performance. The stability requirements in emergency are to be established with due regard for details of operation performance, external loads and reactions, operation duration, consequences of potential damage, etc. To ensure buoyancy and stability, it is to be taken into account the various causes of potential water ingress into the platform and ships including:

ship collisions and the fall of various objects;

mechanical systems failure and failures of bilge pumps power supply, etc.;

non-observance of operation performance conditions and personnel's errors;

exceeding of acceptable parameters of environmental conditions.

2.1.1.2 When stability is calculated, it is not generally recommended to take into account the platform structure parts located above its deck, which may occasionally (in significant rolling) submerge into water. The effect of such structures on platform stability may be admitted in specially agreed cases if properly justified. Where additional solid ballast or loads are used to improve stability, the relevant forces in loads (ballast) securing are to be taken into account.

2.1.1.3 Drainage openings to avoid unacceptable accumulation of water on the platform are to be provided in its structures for the period of marine operation performance. Where such openings are impractical, the platform stability is to be estimated with due regard for the potential additional volume of water.

2.1.1.4 Temporary closing devices of the platform like hatches, blind flanges, plugs and other accessible openings that may be exposed to slamming, etc. are to be designed for appropriate loads. If needed, special protection of such devices is to be provided.

Type and protection of sealings, gaskets and glands are to be carefully considered, as well as relative movement of closing devices and supporting structures in the preparation of a marine operation.

2.1.1.5 All openings between platform compartments, which may cause progressive flooding of the platform during an operation, are to be closed. Regular inspections or air pressure tests for compartments tightness, checks of water level in compartments and tanks, of the platform draught, heel, trim, etc. in search of possible leakage are to be conducted during the operation.

2.1.1.6 In the calculations of stability and reserve buoyancy, due allowance is to be included to account for possible changes in mass, displacements of the platform center of mass, for density of ballast, ballast and sea water. Correction for free surface effects in ballast tanks and other compartments containing liquids are to be included.

2.1.1.7 Planning the operations for which the issues of stability and reserve buoyancy are crucial, the duration of critical situations, the risk of potential hazards and the mobilization time for drain systems and other means ensuring survivability are to be considered.

2.1.1.8 Estimating stability, wind and waves effects are to be assumed in accordance with 2.3, Part II "Hull" of MODU/FOP Rules. If not otherwise specified, the 1-minute average wind velocity is to be assumed in the stability calculations.

2.1.1.9 Inclining tests of floating objects are normally to be performed in the course of platform construction and prior to marine operations to confirm the parameters affecting the stability. The need in such tests is of particular importance when the calculated value of the metacentric height is close to the minimum acceptable value.

2.1.1.10 The inclining test procedure is to take into account the requirements given in 1.5, Part IV "Stability" of MODU/FOP Rules. For floating object with a large metacentric height, an inclining test may not give sufficient accurate results. The stability calculations may then be based on the calculated values of the mass and center of mass location of the structure, and on the data of a platform weight control system in the course of platform construction.

2.1.1.11 Special attention is to be paid to ensuring platform structure watertightness during marine operations performance. The number of openings in watertight bulkheads and decks is to be kept to a minimum. Where penetrations of decks, outer walls and bulkheads are necessary for piping, ventilation and electrical cables, appropriate arrangements are to ensure their watertightness.

The requirements of the International Conference on Load Lines, 1966 are to be followed during operations with respect to air pipes, overboard and inlet pipes, watertight protection of doors, hatches and other openings.

2.1.2 Stability and freeboard.

The specified requirements apply to floating structures whose blocks are launched, outfitted and mated afloat.

The freeboard of intact structures and the support foundation when afloat or during local towing is to be not less than 2 m or be equal to a significant wave height (13 per cent probability of exceeding level) plus 0,5 m, whichever is greater. For a damaged support foundation when water enters one of the tanks or a compartment, the foundation is to remain afloat with a minimum freeboard over the entire perimeter or a minimum freeboard at three towers if afloat supported by towers buoyancy.

2.1.3 Initial metacentric height.

For an intact structure during the long period of being afloat (construction, prolonged sea towing), an initial metacentric height (corrected for free surface effects and effect of possible air cushions in tanks) is to be at least 1,0 m.

For a damaged structure (with a compartment or tank flooded) a metacentric height is to be positive at a static inclination corresponding to an accident within the whole range of inclinations being defined by a dynamic transient process supplemented with a roll amplitude and wind inclination (for weather conditions determined for the given operation and area); it is usually assumed a wind velocity specified for weather conditions and calculated as a 1 min averaged value, and the corresponding roll amplitude.

In the calculations of stability and reserve buoyancy, it is necessary to allow for errors in determination of masses, the center of gravity, ballast and sea water density, and free surface effect in tanks and towers.

Where one or more positioning systems (anchor system, towing lines, mooring lines from ships and buoys, slings from a floating crane) are available, the initial metacentric height is to be computed with regard to the effect (efforts and moments) of the above link systems. In this case, it may be used, for example, the "computerized inclination" technique according to the computer program approved by the Register.

2.1.4 Stability curves.

For structures, while being afloat, within the whole range of draughts, i.e. from the initial draught (at the beginning of construction) till the one corresponding to the mass when floating out from the shipyard, stability curves with respect to the most unfavourable inclination axes are to be plotted.

Where positioning systems are available (anchor system, towing lines, mooring lines from ships and buoys), righting moments curves are to be plotted with regard to the effect of the above link systems. In this case, it may also be used, for example, the "computerized inclination" technique according to the program approved by the Register.

The righting moment curve is to be positive from zero till the angle of heel corresponding to the second intersection of the above curve with the heeling moment curve or till the angle of heel corresponding to the entry into water of the nearest opening assumed opened.

2.1.5 Effect of anchor, mooring and towing lines.

The effect of anchor, mooring and towing lines is to be considered in all the phases of construction and marine operations including the damaged condition of the structure (flooded tanks or towers). In this case, it is to be taken into account both the increase of a heeling moment due to efforts in anchor, mooring and towing lines, and the possibility of the structure draught increase due to the above efforts.

The composition of systems, the length of and tension in anchor and mooring lines are to be specified in a Marine Operation Manual. The procedure of allowing for the systems effect on buoyancy and stability is to be approved by the Register.

2.1.6 Requirements for water ballast system to ensure submersion/emersion stability.

Ballasting systems of shelf structures incorporate water ballast systems including manoeuvrable ballast used for a submersion/emersion and trimming. The marine operations associated with the significant variation of a draught and accordingly of all the characteristics affecting stability, need ballasting. The ballasting system comprising tanks, valves and sea openings is to meet some requirements. Among such requirements are, in particular, to be (but extend further):

the ballasting system capacity is to ensure the design time of a marine operation;

in order to prevent the loss of stability due to simultaneous opening of outboard flooding valves (sea valves) for several tanks or towers, the use of those valves is undesirable;

instructions on the calculation of a stability curve with due regard for the change of a waterline, centers of gravity and buoyancy, and for the corrections for free surface effects in tanks while handling the ballast.

2.2 ADDITIONAL REQUIREMENTS FOR BUOYANCY AND STABILITY

2.2.1 Self-floating structure.

2.2.1.1 For intact structure:

.1 the arm of stability is to be positive to a next inclination angle beyond equilibrium

$$\vartheta \geqslant (\vartheta_{max} + 15 + 15/h), \text{ max } 40^\circ, \tag{2.2.1.1.1}$$

where ϑ_{max} = maximum dynamic inclination due to wind and waves, deg;
h = initial metacentric height, m.

For marine operations of a very short duration covered by reliable weather forecasts (short-time towing, in-site installation), the inclination angle may be $\vartheta \geqslant 15^\circ$;

.2 relationship between the areas formed at the intersection of a righting moment curve and wind heeling moment curve is to be

$$(A + B) \geqslant 1{,}4(B + C) \tag{2.2.1.1.2}$$

where the areas A, B and C are formed as specified in Part IV "Stability" of MODU/FOP Rules.

2.2.1.2 For damaged structure:

.1 the following relationship is to be fulfilled:

$$(A + B) \geqslant (B + C); \tag{2.2.1.2.1}$$

.2 it is to be ensured the strength of watertight bulkheads and tower walls for the hydrostatic pressure corresponding to the submersion of the structure at trim after an accident.

A structure is to remain afloat in equilibrium with one tank or tower flooded and with a freeboard, which ensures the absence of progressive flooding of any other tank or tower.

2.2.2 Transportation and towing.

2.2.2.1 Barge transporting.

A transport barge is to comply with the requirements of the International Conference on Load Lines, 1966.

Relationships (2.2.1.1.1) and (2.2.1.1.2) are to be fulfilled for an intact barge.

When damaged, the barge is to remain afloat in equilibrium with one barge compartment flooded and with a freeboard, which ensures the absence of progressive flooding of any other compartment or tank. The strength of watertight bulkheads and the sufficient strength margin of cargo (structure or its parts) securing on the barge are to be ensured.

Evaluating transport barge stability, the righting moment due to a cargo (structure blocks) entering water is not to be considered. On the contrary, it is to be allowed for the possibility of barge compartment or cargo flooding in the wake of ships impacts, cargo falls, operators mistakes, weather deterioration. For a damaged barge, the relationship (2.2.1.2.1) is to be fulfilled.

2.2.2.2 Towing afloat.

All general and additional requirements of 2.2.1 apply to a structure or platform floating either on its own or with use of temporary buoyancy towers.

A damaged structure, when water enters one of its compartments or tanks or towers, is to remain afloat with a minimum freeboard over its entire perimeter or, as a minimum, at three towers. The progressive flooding of tanks or buoyancy towers therewith is to be prevented.

2.2.2.3 Launching.

The minimum design freeboard of a structure after launching is determined as a significant wave height (set for this operation performance) increased by 0,5 m, but at least 2 m, whichever is greater. In addition, a buoyancy reserve is to ensure a launching trajectory whose the lowest point is to be not less than 5 m above seabed including allowance made for a possibility to damage one compartment in launching. Following launching, the stability is to be positive at the moment of the largest deepening and thereafter, in equilibrium afloat, to meet the general and additional requirements of 2.2.1.2 and 2.2.2.1. In this case, an initial metacentric height for short-term marine operations of a duration under 3 days (launching, short-time towing) is to be at least 0,3 m

Evaluating buoyancy and stability in launching, an emergency flooding of any one tank or compartment or tower is to be taken into account. After a damage, the structure is to have a minimum freeboard over its entire perimeter or, as a minimum, at three towers and a positive metacentric height. The progressive flooding of tanks or buoyancy towers therewith is to be prevented.

2.2.3 Buoyancy and stability during vertical mating by floating and in-site installation.

2.2.3.1 In the process of emersion during vertical mating by floating and of submersion during in-site installation, a metacentric height calculated with due regard for the effect of buoyancy towers (pontoons) and anchor and mooring lines (and slings if a floating crane is used for supporting) is to be positive within the entire range of draughts, and also to meet the additional requirements for stability according to 2.2.1, the case of one compartment, tank or tower flooding inclusive.

N o t e. It is allowed for the specified operations to have a negative metacentric height within the small range (1 m to 2 m) of actual draught variations. In this case, a dynamic inclination is not to exceed 2°, and a static inclination with submersion stopped is not to be more than 1°. This assumption is subject to special consideration by the Register.

Installation of a gravity or piled structure on the seabed calls for ensuring hydrostatic stability during submersion and, thereafter, on-bottom stability after touching the seabed to prevent overturning or sliding of the structure due to environmental loads prior to taking in ballast and/or pile driving. Stability therewith is to be ensured at the expense of an initial metacentric height being in the end of the submersion (1 m to 2 m above the seabed) not less than 1 m. On-bottom stability after touching is to be confirmed by calculations for the absence of shift and uplift of the periphery from the seabed for weather conditions planned for the operation. The same calculations are to be made for the weather conditions which may arise in case of delays or unforeseen events that prevent timely taking in the main ballast, i.e. the flooding of pontoons and/or other parts of the support foundation.

2.2.3.2 Dynamic parameters evaluation.

The dynamic phases of marine operations are to be substantiated by computer modelling which simulates the structure behavior under planned weather conditions with allowance made for their deterioration and with ballasting control both of the intact structure and damaged structure for different versions of damage. The modelling is to be performed according to computer programs approved by the Register.

In order to obtain hydrodynamic initial data for calculations and to confirm the calculations and modelling results, execution of model tests is favoured for all the specified dynamic cases including launching, mating by floating and platform setting on the seabed.

3 REQUIREMENTS FOR STRUCTURES, SYSTEMS AND EQUIPMENT FOR MARINE OPERATIONS SUPPORT

3.1 ARRANGEMENTS AND EQUIPMENT

3.1.1 Platform arrangements and equipment used in marine operations include towing, anchor, mooring, bumper and lifting arrangements, a positioning system, ballast system, arrangements for in-place installation, as well as electrical, mechanical, instrumentation, navigation and other specially-installed systems, devices and equipment which are essential for movement, positioning and installation of a platform in a design position. The listed arrangements and equipment are to ensure platform control during marine operations.

Systems, arrangements and associated equipment are to be designed, fabricated, installed and tested in accordance with the relevant standards and provisions of Part III "Equipment, Arrangements and Outfit of MODU/FOP" of MODU/FOP Rules. Selection of systems and equipment is to be based on a thorough consideration of their conformity to functional and operational requirements for the marine operation. Emphasis is to be placed on reliability and resistance in contingencies.

The issues of platform course-keeping qualities and the relevant equipment are subject to special consideration by the Register.

3.1.2 Towing, anchor, mooring and bumper arrangements are to be designed for all the relevant loads specified in 2.3, Part II "Hull" of MODU/FOP Rules. In design of towing, anchor, mooring and bumper arrangements, the principle of "a weak link" is to be applied which prevents the damage of main components of the structure (arrangement) under occasional overloads exceeding the design ones. The structure is to withstand local loads without the loss of overall strength and stability.

3.1.3 Depending on the complexity and duration of a marine operation, particularly close control over the marine operation conditions and functioning of various systems both in normal and critical situations may be needed to ensure its safe execution. It is generally recommended to consider the following electrical and mechanical systems:

main power plants;

back-up power plants for power supply in extreme situations;

machinery control systems;

valve (slide valve) control systems;

ballast arrangements;

instrumentation systems;

fuel system;

electrical networks;

compressed air systems;

fire-fighting systems;

navigation systems;

communications systems.

3.1.4 Systems and equipment are to be designed, fabricated, installed and tested in accordance with the requirements of MODU/FOP Rules.

3.1.5 All systems, devices and equipment are to be approved and tested before the beginning of the operations in question. The tests are to confirm systems reliability and their conformity to design characteristics.

3.1.6 Instrumentation systems and equipment are generally to ensure monitoring of:

loads and deformations of structures and separate components and arrangements;

environmental conditions;

ballasting and stability conditions;

heel, trim and draught of floating objects;

platform position (navigational parameters);

platform under keel clearance;

platform penetration into the seabed.

3.1.7 The most essential systems and equipment including computer networks, etc. are to be duplicated and to have independent sources of power supply. The reliability of power supply for arrangements and equipment is to be improved with accumulator batteries when the main source of electrical power fails. All systems are to be tested in accordance with Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships. In the regulations for marine operation performance, the time necessary for a change-over or substitution of the system is to be assessed. The requirements for design and fabrication of primary and back-up systems are to be the same. Back-up systems may be used as an integrated part of the primary system. For systems consisting of multiple independent units, the back-up may be provided by having the sufficient number of available spare units. Automatic control systems are to be provided with a possibility for manual overriding.

3.1.8 Non-traditional arrangements and equipment specially-installed on a platform (joining elements, etc.) are to be properly designed and calculated for loads applied to the platform in the course of a marine operation.

For consideration and approval of such arrangements, the following documentation is to be submitted to the Register:

equipment description;

general arrangement drawing;

strength calculations;

material specifications;

specifications for manufacture and installation.

3.1.9 In some cases, in the course of marine operations, the temporary reinforcement or disassembly of separate parts of the platform structure, arrangements and equipment may be needed what is to be properly specified in the design of marine operation performance.

3.2 STRUCTURES

3.2.1 All loads on the platform structure, its arrangements and equipment, and platform displacements are not to exceed the levels set in the design for operation performance. The loads in the course of a marine operation are to be determined in accordance with 2.3, Part II "Hull" of MODU/FOP Rules.

3.2.2 Structural components and details used in marine operations are to be as far as possible flexible and pliable. It is not recommended to use an increased air pressure in floating components or underwater air caissons to improve safety at platform structure damage. This may, however, be exempted from in special cases upon thorough consideration of separate systems like a drain system, etc. with due regard for damage consequences, operation duration, etc.

3.2.3 Developing details of a structure for marine operations, transmission of tensile stresses through the thickness of rolled steel elements (plates, beams, etc.) is, as far as possible, to be avoided. Transmission of concentrated loads to plate structures is to be arranged through intermediate stiffening elements (reinforcements).

3.2.4 Projecting parts of the structure located above the waterline are to be designed so as to prevent trapping of water when submerged into water in platform rolling, etc.

3.2.5 Structural elements and their connections are recommended to group according to the following indication:

type of stress;
presence of cyclic loading;
presence of stress concentrations;
presence of contraction;
loading rate;
consequences of failure.

It is recommended to consider the following categories of structural elements:

special — the most essential parts of primary structural elements which define their strength, carry main loads, undergo stress concentration, etc.

primary — structural elements, which define overall integrity of the structure whose damages, may result in the hazard for human life, etc.

secondary — structural elements of less importance whose damages do not threaten human life or result in significant economic consequences.

The listed categories define requirements for materials and extent of inspection and examination.

3.2.6 Materials quality is to meet design operational conditions, ensure necessary properties (strength, ductility, toughness, weldability, corrosion resistance) and meet the requirements of current standards given in 1.4 to 1.6, Part II "Hull" of MODU/FOP Rules.

EQUIPMENT
OF MOBILE OFFSHORE DRILLING UNITS (MODU)
AND FIXED OFFSHORE PLATFORMS (FOP)

PART I. SIGNAL MEANS

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the present Part apply to signal means of MODU and FOP.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 The definitions and explanations relating to general terminology are given in the General Regulations for the Classification and Other Activity and in Part I "Classification" of the Rules for the Classification, Construction and Equipment of MODU/FOP[1].

1.2.2 The definitions and explanations relating to signal means are given in Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships.

1.2.3 For the purpose of this Part, the following definitions have been adopted.

Height above the hull is the distance from the place of the lantern installation to the upper deck of self-elevating MODU, FOP and drilling ships or to the top edge of stability columns of submersible and semi-submersible MODU.

Competent body is a ministry, government institution or other administration authorized to issue rules, directives and other statutory instructions.

2 EQUIPMENT OF MODU AND FOP WITH SIGNAL MEANS

2.1 Each MODU/FOP is to be provided with the following signal means:

.1 navigation lights in accordance with 2.2.1 of Part III "Signal Means" of the Rules for the Equipment of Sea-Going Ships;

.2 relevant light and sound means of warning and navigational equipment (see 3.2 and 4.2);

.3 portable daytime signal light;

.4 relevant light signals for helicopter landing (see 3.2 and 4.2);

.5 parachute red flares — 12 pcs;

.6 one-star red flares — 12 pcs;

.7 one-star green flares — 12 pcs;

.8 sound signal flares — 12 pcs;

2.2 FOPs are to be provided with signal means in accordance with 2.1 except that the navigation lights required in 2.1.1 may be fitted only temporarily for the period of the FOP's transit to a drilling position.

3 SIGNAL MEANS DESIGN

3.1 The navigation lights required for the FOP in 2.1.1 may be non-electric. In this case, their design and construction are subject to special consideration by the Register.

3.2 Choice of types, characteristics and design of means and equipment specified in 2.1.2 and 2.1.4 is subject to technical supervision by the competent body.

[1]Hereinafter referred to as "MODU/FOP Rules".

4 INSTALLATION OF SIGNAL MEANS

4.1 Sidelights, masthead and stern lights are to be fitted at the height of not more than 30 m above the sea level.

4.2 Installation of means and equipment specified in 2.1.2 and 2.1.4 is subject to technical supervision by a competent body.

PART II. LIFE-SAVING APPLIANCES

1 GENERAL

1.1 Application, definitions and explanations related to the types of mobile offshore drilling units and fixed offshore platforms are specified in Section 1, Part I "Classification" of MODU/FOP Rules.

1.2 The installation of life-saving appliances on board units of other purpose is subject to special consideration by the Register.

1.3 Unless provided otherwise in the present Part, the life-saving appliances of MODU/FOP as well as of surface units and drilling ships and also their arrangement, installation and supervision are to comply with all applicable requirements of General Regulations for the Classification and Other Activity, Part I "Survey Regulations" and Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships.

1.4 Life-saving appliances and launching arrangements, and also their equipment items are to be reliable in use during operation under intended climatic conditions.

1.5 Ice-resistant FOP are to have survival craft whose technical parameters ensure the evacuation and rescue of personnel under ice conditions.

2 SURVIVAL CRAFT

2.1 EQUIPMENT OF SURFACE UNITS

2.1.1 Each surface unit is to be provided on each side with one or more lifeboats, complying with the requirements of 6.18, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships of an aggregate capacity sufficient to accommodate the total number of persons on board.

2.1.2 In addition to the requirements of 2.1.1, each surface unit is to be provided with a liferaft/liferats complying with the requirements of 6.8 to 6.12, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships, capable of being launched on either side of the unit and having an aggregate capacity sufficient to accommodate the total number of persons on board.

If liferafts cannot be readily transferred for launching on either side of the unit, the total capacity of the liferafts available on each side is to be sufficient to accommodate the total number of persons on board.

2.1.3 Where the survival craft are stowed in a position which is more than 100 m from the stem or stern, the surface unit is to carry, in addition to the lifecrafts required by 2.1.2, a liferaft stowed as far forward or aft, or one as far forward and another as far aft, as is reasonable or practicable.

Such liferafts are to be securely fastened so as to permit manual release.

2.2 EQUIPMENT OF SELF-ELEVATING UNITS, COLUMN-STABILISED UNITS AND FOP

2.2.1 Each MODU/FOP is to be provided with lifeboats complying with the requirements of 6.18, Part II "Life-Saving Appliances" of the Rules for the Equipment of Sea-Going Ships, installed in at least two widely separated locations on different sides or ends of MODU/FOP.

The aggregate capacity of the lifeboats installed in such locations is to be sufficient to accommodate the total number of persons on board if:

.1 all the lifeboats in any one location are lost or rendered unusable;

.2 all the lifeboats on any one side, any one end, or any one corner of the unit are lost or rendered unusable.

2.2.2 In addition, each MODU/FOP is to be provided with liferafts complying with the requirements of 6.8 to 6.12, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships, of an aggregate capacity sufficient to accommodate the total number of persons on board.

If the liferafts cannot be transferred for launching on any side of the MODU/FOP, the aggregate capacity of the liferafts available on each side is to be sufficient to accommodate the total number of persons on board.

2.2.3 In the case of a self-elevating MODU where, due to its size or configuration, lifeboats cannot be installed according to 2.2.1, the Register may permit the aggregate capacity of the lifeboats sufficient to accommodate the total number of persons on board.

In this case, the liferafts required by 2.2.2 are to be served by launching appliances complying with the requirements of 6.20.5, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships.

2.2.4 The Register may permit to reduce the total number of survival craft when MODU/FOP being towed have the incomplete number of personnel on board.

In this case, the number of survival craft complying with the requirements of the present Part is to be sufficient to accommodate the total number of persons on board the MODU/FOP in tow.

2.2.5 Provision of free fall launched lifeboats for the FOPs designed for operation under ice conditions is subject to special consideration by the Register.

2.3 EQUIPMENT OF DRILLING SHIPS

2.3.1 Drilling ships are to be provided with survival craft according to the standards for oil tankers carrying cargo having a flashpoint not exceeding 60 °C as required by Section 4, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships.

3 EQUIPMENT OF MODU WITH RESCUE BOATS

3.1 Each MODU/FOP, fixed unit and each drilling ship is to be provided with at least one rescue boat complying with the requirements of 6.19, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships.

3.2 A lifeboat may be accepted as a rescue boat provided that it meets the requirements for rescue boats.

4 PERSONAL LIFE-SAVING APPLIANCES

4.1 EQUIPMENT OF MODU/FOP, SURFACE UNITS AND DRILLING SHIPS WITH LIFEJACKETS

4.1.1 A lifejacket complying with the requirements of 6.3, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships is to be provided for every person on board the MODU/FOP, surface unit or drilling ship.

4.1.2 In addition to the requirements of 4.1.1, each unit or each ship is to be provided with lifejackets for the watch keeping personnel, and also a sufficient number of lifejackets is to be located in accessible places for the members of industrial personnel who may be on duty in locations where their lifejackets are not readily accessible.

4.1.3 Additional lifejackets for the maximum permissible number of helicopter passengers are to be provided in way of a helicopter deck.

4.1.4 Each lifejacket is to be fitted with a light complying with the requirements of 6.3.3, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships.

4.2 EQUIPMENT OF MODU/FOP, SURFACE UNITS AND DRILLING SHIPS WITH LIFEBUOYS

4.2.1 At least eight lifebuoys complying with the requirements of 6.2, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships are to be provided on each MODU/FOP, surface unit or drilling ship.

The number and location of lifebuoys are to be such that they are placed in the open and be readily accessible.

Surface units and drilling ships over 100 m in length as well as FOP dimensioned over 100 m in any horizontal direction are to be provided with lifebuoys according to Table 4.2.1.

4.2.2 Not less than one-half of the total number of lifebuoys is to be provided with self-igniting lights

Table 4.2.1

Length, in m	Minimum number of lifebuoys
More than 100, but under 150	10
150, but under 200	12
200 and over	14

complying with the requirements of 6.2.2, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships, with approved source of power.

Not less than two of these are to be also provided with self-activating smoke signals complying with the requirements of 6.2.3, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships and be capable of quick release from the navigating bridge, main machinery control room, or a location readily available to operating personnel.

Lifebuoys provided with lights and those with lights and smoke signals are to be equally distributed on both sides of the unit or ship and are not to be provided with lifelines (see 4.2.3).

4.2.3 At least two lifebuoys in widely separated locations are to be provided with a lifeline, the length of which is to be at least one-and-a half times the distance from the deck of stowage to the waterline at light draught or 30 m, whichever is greater.

4.2.4 Each lifebuoy is to be marked in capital letters of the Roman alphabet with the name and port of registry of the unit or ship.

4.3 EQUIPMENT OF MODU/FOP, SURFACE UNITS AND DRILLING SHIPS WITH IMMERSION SUITS

4.3.1 Each MODU/FOP and surface unit is to be provided with immersion suits complying with the requirements of 6.4, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships for the total number of persons on board.

In addition, a sufficient number of immersion suits is to be located in accessible places for watch-keeping personnel, and also for those members of industrial personnel who may be on duty in locations where their immersion suits are not readily accessible.

4.3.2 On agreement with the Register, immersion suits may be omitted if the MODU/FOP and surface units are constantly in operation in warm climates.

4.3.3 Drilling ships are to be provided with immersion suits according to the standards for cargo ships as required by Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships.

5 LIFEBOATS, LIFERAFTS AND RESCUE BOATS ARRANGEMENT. LAUNCHING STATIONS

5.1 Muster stations are to be provided as close to the embarkation stations as possible. Each muster station is to have sufficient space to accommodate all persons assigned to muster at that station.

5.2 Muster and embarkation stations are to be readily accessible from accommodation and work areas.

5.3 Muster and embarkation stations are to be adequately illuminated by lighting supplied form the main and emergency sources of power required by Part X "Electrical Equipment" of MODU/FOP Rules.

5.4 Alleyways, stairways and exits giving access to the muster and embarkation stations are to be adequately illuminated by lighting supplied form the main and emergency sources of power required by Part X "Electrical Equipment" of MODU/FOP Rules.

5.5 Davit-launched lifeboats and liferafts muster and embarkation stations are to be so arranged as to enable stretcher cases to be placed in survival craft.

5.6 Lifeboats and liferafts embarkation arrangements are to be so designed that:

.1 lifeboats can be boarded by their full complement of persons within 3 min from the time the instruction to board is given;

.2 lifeboats can be boarded and launched directly from the stowed position;

.3 davit-launched liferafts can be boarded and launched from a position immediately adjacent to the stowed position or from a position to which the liferaft is transferred prior to launching in compliance with 6.6;

.4 where necessary, means are to be provided for bringing the davit-launched liferafts against the unit's side and holding them alongside so that persons can be safely embarked.

5.7 At least two widely separated fixed metal ladders or stairways are to be provided extending from the deck to the water surface. The fixed metal ladders or stairways and water surface in their vicinity are to be adequately illuminated by lighting supplied form the main and emergency sources of power required by Part X "Electrical Equipment" of MODU/FOP Rules.

5.8 If fixed ladders cannot be installed, alternative means of escape with sufficient capacity to permit all persons on board to descent safely to the waterline are to be provided.

5.9 Launching stations are to be in such positions as to ensure safe launching having particular regard to clearance from any exposed propeller. As far as possible, launching stations are to be located so that lifeboats and liferafts can be launched down the straight side of the unit, except for:

.1 survival craft specially designed for free-fall lunching;

.2 survival craft mounted on structures intended to provide free launching.

5.10 The rescue boat embarkation and launching stations are to be such located that the rescue boat can be boarded and launched in the shortest possible time.

5.11 Lifeboats, liferafts and resque boats arrangement as well as launching stations of drilling ships are to comply with the requirements of Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships.

6 STOWAGE OF LIFEBOATS, LIFERAFTS AND RESCUE BOATS

6.1 Survival craft are to be located so as to provide easy access to these craft embarkation stations and into all embarkation hatches as well as the maximum distance from hazardous spaces and areas.

6.2 Each lifeboat or liferaft is to be stowed:

.1 so that neither they nor their stowage arrangements will interfere with the operation of any other survival craft or rescue boat at any other launching station;

.2 as near the water surface as it is safe and practicable;

.3 in a state of continuous readiness so that two crew members can carry out preparations for embarkation and launching in not more than 5 min;

.4 as far as practicable, in a secure and protected place to prevent their damage by fire and explosion.

Each lifeboat or liferaft is to be stowed fully equipped as required by 6.8.5 or 6.13.8, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships. However, in case of units operating in areas such that, in the Register opinion, certain items of equipment are unnecessary, these items may be dispensed with.

6.3 If possible, the unit is to be so arranged that lifeboats attached to launching appliances are protected from damage by heavy seas.

6.4 Lifeboats are to be stowed attached to launching appliances.

6.5 Liferafts are to be so stowed as to permit manual release from their securing arrangements.

6.6 Davit-launched liferafts are to be stowed within reach of the lifting hooks, unless some means of transfer is provided which is not rendered inoperable within the limits of trim and list prescribed in Part V "Subdivision" of MODU/FOP Rules for any damaged condition or by unit motion or power failure.

6.7 Every liferaft, other than those specified in 2.1.3, is to be stowed with the weak link of its painter permanently attached to the unit and with a float-free arrangement complying with the requirements of 6.8.6, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships so that the liferaft floats free and, if inflatable, inflates automatically when the unit sinks.

6.8 Rescue boats are to be stowed:

.1 in a state of continuous readiness for launching in not more than 5 min;

.2 in a position suitable for launching and recovery;

.3 so that neither the rescue boat nor its stowage arrangement will interfere with the operation of any other survival craft at any other launching station;

.4 in compliance with 5.1 to 5.4.

6.9 On drilling ships lifeboats, liferafts and rescue boats are to be stowed in compliance with the requirements of Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships.

7 LIFEBOATS, LIFERAFTS AND RESCUE BOATS LAUNCHING AND RECOVERY ARRANGEMENTS

7.1 Launching appliances complying with the requirements of 6.20.1 and 6.20.2, 6.20.4 or 6.20.5, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships, as applicable, are to be provided for all lifeboats and liferafts. Notwithstanding the requirement of 6.20.1.1, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships, for column-stabilised MODU, launching appliances are to be capable of operating at the heel and trim resulting from any damaged condition under Part V "Subdivision" of MODU/FOP Rules.

7.2 Launching and recovery arrangements are to be such that the appliance operator on the unit is able to observe the lifeboat or liferaft at all times during launching and lifeboats during recovery.

7.3 Only one type of release mechanism is to be used for similar survival craft carried on board the unit.

7.4 Preparation and handling of lifeboat or liferaft at any one launching station is not to interfere with the prompt preparation and handling of any other lifeboat or liferaft or rescue boat at any other station.

7.5 Falls, where used, are to be long enough for the lifeboat or liferaft to reach the water with the unit under unfavourable conditions such as lightest transit or operational condition or any damaged condition, as described in Part V "Subdivision" of MODU/FOP Rules.

7.6 During preparation and launching, lifeboats and liferafts, their launching appliance and the area of water into which it is to be launched are to be adequately illuminated by lighting supplied form the main and emergency sources of power required by Part X "Electrical Equipment" of MODU/FOP Rules.

7.7 Means are to be available to prevent any discharge of water onto lifeboats and liferafts during abandonment.

7.8 All lifeboats required for abandonment by the total number of persons permitted on board, are to be capable of being launched with their full complement of persons and equipment within 10 min from the time the signal to abandon the unit is given.

7.9 Manual brakes of a launching appliance are to be so arranged that the brake is always applied unless the operator, or a mechanism activated by the operator, holds the brake control in the "off" position.

7.10 Each lifeboat or liferaft is to be so arranged as to clear each leg, column, footing, brace, mat and each similar structure below the hull of a self-elevating unit and below the upper hull of a column-stabilised unit in an intact condition.

7.11 In any case of damage specified in Part V "Subdivision" of MODU/FOP Rules, lifeboats with an aggregate capacity of not less than 100 per cent of persons on board are to, in addition to meeting all other requirements for launching and stowage contained in the present Part, be stowed so as to be capable of being freely launched.

7.12 During MODU design particular consideration is to be given to the location and orientation of lifeboats and liferafts in order that clearance of the unit is achieved in an efficient and safe manner having due regard to the capabilities of survival craft.

7.13 Notwithstanding the requirement of 6.20.2.8, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships, the speed of launching is not to be more than 1 m/s.

7.14 Launching arrangements for rescue boats are to meet the requirements of 7.1 to 7.13.

7.15 Rapid recovery of the rescue boat is to be possible when loaded with its full complement of persons and equipment. If the rescue boat is also a lifeboat, rapid recovery is to be possible when loaded with its full complement of equipment and a crew consisting of at least 6 persons.

8 LINE-THROWING APPLIANCES

8.1 Each MODU, FOP and surface unit is to be provided with one set of a line-throwing appliance complying with the requirements of 6.21, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships.

9 RADIO EQUIPMENT FOR LIFE-SAVING APPLIANCES

9.1 Each lifeboat of MODU/FOP and surface unit is to carry a two-way VHF radiotelephone apparatus. In addition, at least two such apparatus are to be available on each MODU/FOP and surface unit, so stowed that they can be rapidly placed in any liferaft. All two-way VHF radiotelephone apparatus are to meet the requirements of Section 14, Part IV "Radio Equipment" of Rules for the Equipment of Sea-Going Ships.

9.2 Each lifeboat of MODU/FOP and surface unit is to carry a radar transponder. In addition, at least two radar transponders are to be available on each MODU/FOP and surface unit, so stowed that they can be rapidly placed in any liferaft, excepting liferafts required by 2.1.3. All radar transponders are to meet the requirements of Section 10, Part IV "Radio Equipment" of Rules for the Equipment of Sea-Going Ships.

9.3 On drilling ships, the radio equipment for life-saving appliances are to meet the requirements of 2.1.1, Part II "Life-Saving Appliances" of Rules for the Equipment of Sea-Going Ships.

PART III. RADIO EQUIPMENT

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of the Part apply to the radio equipment of MODU/FOP in addition to the requirements of Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.

2 FITTING OF MODU/FOP WITH RADIO EQUIPMENT

2.1 MODU/FOP SUBDIVISION INTO GROUPS

2.1.1 To define the standard complement of radio equipment, all MODU/FOP are subdivided into three groups:

.1 self-propelled MODU when under way or accompanied by escort ships;

.2 non-self-propelled MODU when towed;

.3 MODU/FOP under operational or severe storm conditions.

2.2 LIST OF RADIO EQUIPMENT

2.2.1 Depending on the sea area, each MODU of the 1st group is to be provided with radio equipment in accordance with the requirements of Section 2, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.[1]

2.2.2 Each MODU/FOP of the 2nd group is to be provided with radio equipment depending on the radio equipment complement of towing or escorting ship[1].

Where the towing or escorting ship is equipped in accordance with the requirements of Section 2, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships, the MODU/FOP is to be provided with the following radio equipment:

.1 VHF radio installation;

.2 MF radio installation;

.3 VHF EPIRB or satellite EPIRB depending on the sea area;

.4 equipment for reception of maritime safety information depending on the sea area: NAVTEX service receiver, EGC receiver and HF direct-printing radiotelegraph receiver.

Where the ship towing or escorting the MODU/FOP is not equipped in accordance with the requirements of Section 2, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships, the MODU/FOP is to be provided with full list of radio equipment complying with the requirements of Section 2, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.

2.2.3 Each MODU/FOP of the 3rd group is to be provided with the main and duplicating radio equipment in accordance with Table 2.2.1 and 2.6.3, Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships depending on the sea area in which it stays[1].

2.2.4 Each MODU/FOP serviced by helicopters is to be provided with the two-way VHF radiotelephone apparatus for communication with aircraft.

2.2.5 Each MODU/FOP is to be provided with effective means of communication between the main machinery control room, navigating bridge (if any) and any station or stations, which have means of radio equipment control.

2.2.6 MODU/FOP constructed on or after 1 July 2004, are to be fitted with a security alarm system. MODU/FOP constructed before 1 July 2004, are to be fitted with the security alarm system not later than the first survey of the radio equipment after 1 July 2006.

2.2.7 All the MODU/FOP radio equipment is to meet the technical requirements given in Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships and the radio equipment installed in hazardous zones or being portable is to be of intrinsically safe type.

[1] The conditions for equipping ships with radar transponders and two-way VHF radiotelephone apparatus are set out in Section 9, Part II "Life-Saving Appliances" of the Rules for the Equipment of MODU and FOP.

3 RADIO EQUIPMENT ARRANGEMENT

3.1 The control of radio equipment is to be carried out from the position where the MODU/FOP is routinely controlled when under way or in tow and where a constant watch is kept while the MODU/FOP is under operational or severe storm condition.

3.2 The duplicating radio equipment of the 3rd MODU/FOP group is to be arranged in a space, which can be navigating bridge or an emergency control room, placed as far as possible from the location of the main radio equipment so that no single accident in any part of the MODU/FOP could disable all the means of radio communications.

3.3 If under operational conditions of the MODU/FOP the acoustic noise level in spaces fitted with radio equipment is high and may interfere or in the proper use of radio equipment, then the relevant noise protection is to be provided.

4 AERIALS

4.1 Transmitting aerials are to be located outside hazardous zones.

4.2 All transmitting and receiving aerials are not to be within 9 m from a drilling rig, cargo crane booms and other high metal structures, which can give rise to screening effect.

PART IV. NAVIGATIONAL EQUIPMENT

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of this Part apply to the MODU/FOP navigational equipment and supplement the requirements of Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 The definitions and explanations relating to general terminology are given in the General Regulations for the Classification and Other Activity and in Part I "Classification" of the MODU/FOP Rules.

1.2.2 The definitions and explanations relating to navigational equipment are given in Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

2 LIST OF MODU/FOP NAVIGATIONAL EQUIPMENT

2.1 GENERAL

2.1.1 The MODU/FOP navigational equipment is to be installed in such a number and to have such technical performance as to ensure:

.1 determination of its own position and observation of surrounding conditions;

.2 the independent navigational support of a self-propelled MODU in sea transit while following to a drilling position and coming back to the port of registry.

2.1.2 In order to determine the list of navigational equipment, the drilling units are divided into the following groups:

.1 self-propelled MODU;

.2 non-self-propelled (towed) MODU and FOP.

2.2 LIST OF MODU/FOP NAVIGATIONAL EQUIPMENT

2.2.1 Depending on the group to which the drilling units are related, the MODU/FOP are to be provided with the navigational equipment in accordance with Table 2.2.

The MODU/FOP constructed after 1 July 1994 and fitted with the 2nd and 3rd class dynamic positioning systems (see 7.5, Part XIV "Automation" of the MODU/FOP Rules) are to have means for the receipt of information from at least three positioning systems based on different principles. The drilling units provided with the 2nd class dynamic positioning systems are to be fitted with three gyrocompasses.

Table 2.2

Nos	Item	Quantity in groups	
		Self-propelled	Non-self-propelled
1	Standard magnetic compass	1	—
2	Steering magnetic compass installed at the main steering position	1	—
3	Gyrocompass[1]	1	—
4	Dynamic pressure log, induction log or other of a ground type[1]	1	—
5	Echo sounder	1	—
6	Automatic identification system (AIS) equipment	1	1
7	Radionavigation system/systems receiver	1	1
8	Hand lead[1]	1	—
9	Navigational sextant	1	—
10	Chronometer	1	—
11	Stopwatch	2	1
12	Prismatic binocular	3	2
13	Anemometer	1	1
14	Barometer	2	1
15	Inclinometer	2	2
16	Sea water and air temperature indicator	1	1
17	Wave parameters indicator	1	1
18	Sea current speed and direction indicator	1	1

[1] For drilling ships only.

3 NAVIGATIONAL EQUIPMENT ARRANGEMENT

3.1 All the navigational devices listed in Table 2.2 are to be installed in the control station.

All deviations from the above requirements due to the MODU/FOP peculiarities are subject to special consideration by the Register. The navigational equipment fed by electric power is not to be installed in hazardous spaces and areas unless it is of the appropriate intrinsically safe type.

PART V. EQUIPMENT FOR PREVENTION OF POLLUTION

1 GENERAL

1.1 APPLICATION

1.1.1 The requirements of this Part apply to the MODUs/FOPs under construction.

1.2 DEFINITIONS AND EXPLANATIONS

1.2.1 For the purpose of this Part, the following definitions have been adopted.

Harmful substance means any substance, which, if introduced into the sea, is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea.

Discharge, in relation to harmful substances or effluents containing such substances, means any release howsoever caused from a ship and includes any escape, disposal, spilling, leaking, pumping, emitting or emptying.

Discharge does not include:

dumping within the meaning of the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, 1972, i.e.;

any intentional disposal of wastes and other matter from ships, aircraft, platforms or man-made offshore structures;

any intentional burial in the sea of ships, aircraft, platforms or man-made offshore structures;

release of harmful substances directly arising from the exploration, exploitation and associated offshore processing of sea-bed mineral resources;

release of harmful substances for purposes of legitimate scientific research into pollution abatement or control.

Ship means a vessel of any type whatsoever operating in the marine environment and includes hydrofoil boats, air-cushion vehicles, submersibles and mobile offshore drilling units and platforms.

1.3 TECHNICAL DOCUMENTATION

1.3.1 Before the beginning of the MODU/FOP const-ruction the technical design documentation is to be submitted to the Register for examination and approval in the scope sufficient to confirm that the requirements of the Rules applicable to the given MODU/FOP are fulfilled.

1.3.2 The technical documentation is to include:

.1 ship's specification (no approval stamps are needed) and a note to the effect the ship complies with MARPOL 73/78;

.2 arrangement plan of equipment and arrangements for prevention of pollution from ships;

.3 calculation of required capacity of holding and other tanks, of tanks for oil residues (sludge), oily water and sewage, of garbage containers and also their arrangement plans (no stamps of approval are needed);

.4 piping diagrams.

2 REQUIREMENTS FOR EQUIPMENT AND ARRANGEMENTS FOR PREVENTION OF POLLUTION BY OIL

2.1 APPLICATION

2.1.1 The requirements of this Section of the Rules apply to the construction of the MODU/FOP, their arrangements and systems intended for the prevention of pollution by oil.

2.2 DEFINITIONS AND EXPLANATIONS

2.2.1 For the purpose of this Section the following definitions have been adopted.

Oil means petroleum in any form including crude oil, fuel oil, oil residues, sludge and petroleum products.

Oily mixture means a mixture with any oil content.

Oily waste means oil residues (sludge) and oily bilge water.

Oil residues means separated sludge, drain and leakage oil, and exhausted oils.

Oil sludge means part of oil, which due to its consistence is not liable to conventional pumping or processing and requires special methods and devices for its disposal from the ship.

E x h a u s t e d o i l means exhausted lubricating oil, hydraulic oil or other hydrocarbon based liquid which is not suitable for use in machinery due to deterioration and contamination.

S e p a r a t e d s l u d g e means sludge resulting from purification of fuel oil and lubricating oil.

1 5 p p m a l a r m means a device signalling whenever the oil content in the effluent exceeds 15 parts per million.

B i l g e w a t e r t a n k means a tank for accumulating oily bilge water.

1 5 p p m s e p a r a t o r means any combination of a separator and filter/coalescer, and also a single unit designed to produce an effluent with oil content not exceeding 15 ppm.

S l u d g e t a n k s means tanks for accumulating separated sludge, drain and leakage oil, and exhausted oils.

2.3 SCOPE OF SUPERVISION

2.3.1 General provisions for the procedure for supervision of the equipment and arrangements for the prevention of pollution by oil, of their manufacture and survey, and also the requirements for the technical documentation submitted to the Register for examination and the instructions on the documents issued by the Register for these equipment and arrangements are given in the General Regulations for the Classification and Other Activity.

2.3.2 Subject to the supervision of the Register during manufacture are:

.1 15 ppm separator;

.2 15 ppm alarms;

.3 standard discharge connection for bilge water disposal;

.4 oily water pumping, piping and discharge system.

2.3.3 The technical documentation listed below is to be submitted to the Register for examination and approval prior to the beginning of manufacture:

2.3.3.1 For 15 ppm separator:

.1 technical description and operating principle, operating instruction and maintenance manual (no stamps of approval are needed);

.2 general view drawings with sectional views (separator and filter design, main dimensions, materials and coatings used);

.3 assembly drawings of pumps and other devices constituting the 15 ppm separator;

.4 drawings of welded assemblies (casings, bedplates and other parts) containing welding details;

.5 diagrams of servicing systems within the 15 ppm separator;

.6 circuit diagram, diagrams of control, regulation, monitoring, signalling and protection;

.7 test program for prototype and series specimens;

.8 list of essential parts with indication of mechanical properties of material and hydraulic test pressure;

.9 list of spare parts.

2.3.3.2 For 15 ppm alarms:

.1 technical description and operating principle, operating instruction and maintenance manual (no stamps of approval are needed);

.2 general view drawings;

.3 specification with indication of materials used and accessories;

.4 circuit and block diagrams;

.5 drawings of device for automatic stop of discharge (if any);

.6 test program for prototype and series specimens;

.7 list of spare parts.

2.3.3.3 For a standard discharge connection for bilge water disposal:

.1 assembly drawings of the standard discharge connection with indication of materials used and hydraulic test pressure.

2.3.3.4 For oily water pumping and discharge systems:

.1 elementary diagram.

2.4 TESTS IN OPERATION

2.4.1 Following assembly, adjustment and running-in, but prior to installation on board ships, the equipment, arrangements and devices are to be bench tested according to the Register approved program.

In individual cases, on agreement with the Register, the bench tests may be substituted by the tests on board ships.

2.5 GENERAL TECHNICAL REQUIREMENTS

2.5.1 Materials used for the manufacture of equipment and arrangements, and the application of welding therewith are to meet the relevant requirements of Part XII "Materials" and Part XIII "Welding" of the MODU/FOP Rules, respectively.

2.5.2 The parts of equipment and arrangements, which are in contact with medium causing corrosion, are to be made of corrosion-resistant materials or to have anti-corrosion coatings.

2.5.3 Automatic and remote control and measuring systems, as well as associated alarm, indication, protection and recording devices are to meet the requirements of Part XIV "Automation" of the MODU/FOP Rules.

2.5.4 Pipelines and systems of equipment and arrangements are to meet the relevant requirements of Part VIII "Systems and Piping" of the MODU/FOP Rules.

2.5.5 Electrical equipment of machinery and arrangements is to meet the requirements of Part X "Electrical Equipment" of the MODU/FOP Rules.

2.5.6 Pumps used for transfer of oily mixtures are to meet the requirements of Part VII "Machinery Installations and Machinery" of the MODU/FOP Rules.

2.5.7 The casings of separators, filters and other items of 15 ppm separator under pressure, being subject to the requirements of Part IX "Boilers, Heat Exchangers and Pressure Vessels" of the MODU/FOP Rules, are to meet the above Rules in respect of the materials used and scantlings.

2.6 REQUIREMENTS FOR 15 PPM SEPARATORS

2.6.1 The design of a 15 ppm separator is to ensure its reliable operation at the angles up to 22,5° in any plane from the normal operation position.

2.6.2 The 15 ppm separators operating under excessive pressure are to be fitted with safety devices prior to applying protective coating. The safety device is to be set to the pressure equal to $P_{open} = 1{,}1p$, where p = working pressure.

2.6.3 The components of the 15 ppm separator operating under excessive pressure prior to applying protective coating are to be subjected to the hydraulic test pressure at $P_{test} = 1{,}5p$, where p = working pressure.

It is permitted to test these components separately space by space at the test pressure prescribed according to the working pressure in each space.

2.6.4 The 15 ppm separator is to be reliably designed and be suitable for shipboard installation. Units and components liable to periodical inspection and maintenance are to be readily accessible for attending personnel. The capacity of the associated pumps is to be consistent with the capacity of the 15 ppm separator. In any case, the capacity of the above pumps is not to exceed more than 1,1 times the capacity of the 15 ppm separator.

2.6.5 Provision is to be made for the drainage of the 15 ppm separator.

2.6.6 If intended to be fitted in locations where flammable air mixtures may be present, the 15 ppm separator is to comply with the relevant safety regulations for such spaces. Any electrical equipment which is part of the 15 ppm separator is to be based in a non-hazardous area, or is to be approved by the Register as safe for use in a hazardous area and meet the requirements of Part X "Electrical Equipment" of the MODU/FOP Rules. Any moving parts, which are fitted in hazardous areas are to be constructed so as to avoid the formation of static electricity.

2.6.7 The 15 ppm separator is to be so designed that it functions automatically. However, fail-safe arrangements to avoid any discharge in case of malfunction are to be provided.

2.6.8 Changing the feed to the 15 ppm separator from bilge water to oil, bilge water to emulsified bilge water, or from oil and/or water to air is not to result in the discharge overboard of any mixture containing more than 15 ppm of oil.

2.6.9 The system is to require the minimum of attention to bring it into operation. In the case of equipment used for engine room bilges, there is to be no need for any adjustment to valves and other equipment to bring the system into operation. The equipment is to be capable of normal operation for at least 24 hours unattended.

2.6.10 The 15 ppm separators, pumps and other equipment are to be fitted with devices for pressure, temperature and level control, as well as an alarm and protection system.

2.6.11 If a centrifugal separator is part of the 15 ppm separator, it is to meet the requirements of Part VII "Machinery Installations and Machinery" of the MODU/FOP Rules.

2.6.12 The 15 ppm separators, pumps and other equipment in places of the potential leakage of oily waters are to be fitted with arrangements for collecting leakages, which meet the requirements of Part VIII "Systems and Piping" of MODU/FOP Rules.

2.7 THE 15 PPM ALARM

2.7.1 The 15 ppm alarm is to be corrosion-resistant in conditions of the marine environment.

2.7.2 The 15 ppm alarm, if intended to be fitted in locations where flammable air mixtures may be present, is to comply with the relevant safety regulations for such spaces. Any electrical equipment which is part of the 15 ppm alarm is to be placed in a non-hazardous area, or is to be approved by the Register as safe for use in a hazardous area. Any moving parts which are fitted in hazardous areas are to be designed so as to avoid the formation of static electricity.

2.7.3 The 15 ppm alarm is not to contain or use any substance of a dangerous nature, unless adequate arrangements, approved by the Register, are provided to eliminate any hazards introduced thereby.

2.7.4 The response time of the 15 ppm alarm, that is the time which elapses between an alteration in the liquid being supplied to the 15 ppm alarm and the ppm display showing the correct response, is not to exceed 5 s.

2.7.5 The 15 ppm alarm is to be fitted with an electrical/electronic device which is to be pre-set by the manufacturer to activate when the oil content in the effluent exceeds 15 ppm. This device is to also operate automatically in case the 15 ppm alarm fails to operate, requires a warm-up period or is de-energized.

2.7.6 It is recommended to provide aboard ship simple means for checking instrument drift, repeatability of the instrument reading and the ability to re-zero the instrument.

2.7.7 The 15 ppm alarm is to record date, time, alarm status and operating status of the 15 ppm separator. The recording device is to also store data for at least eight months and is to be able to display or print a report for official inspections as required. In case of the 15 ppm alarm replacement, measures are to be provided to ensure the data recorded remains available on board for 18 months.

2.7.8 To avoid willful manipulation of 15 ppm alarms, every access that requires breaking of the seal is to be precluded. Besides, the 15 ppm alarm is to be so designed that the alarm is always activated whenever clean water is used for cleaning or zeroing purposes.

2.7.9 The accuracy of the 15 ppm alarms is to be checked according to the manufacturers instructions.

2.7.10 The sampling system shall convey representative samples. Provision is to be made for sampling points on all discharge piping to be monitored. A sampling device is to be fitted on the vertical section of the discharge pipeline. The Register may permit the sampling device to be fitted on the horizontal section if it is ensured that the pipe runs full of liquid all the time during the discharge.

2.8 AUTOMATIC DISCHARGE-STOPPING DEVICE

2.8.1 The automatic discharge-stopping device is to ensure the stoppage of oily mixture discharge by a signal of the device specified in 2.7.

2.8.2 The automatic discharge-stopping device is a device used, where applicable, to automatically stop any discharge overboard of oily waters when the oil content in the effluent exceeds 15 ppm. The automatic stopping device is to consist of a valve arrangement installed in the effluent outlet line of the 15 ppm separator which automatically diverts the oily waters from being discharged overboard back to the ship's bilges or bilge tanks when the oil content in the effluent exceeds 15 ppm.

2.9 PUMPING, PIPING AND DISCHARGE ARRANGEMENTS FOR OILY WATERS

2.9.1 Pumping, piping and discharge arrangements for oily waters and the hydraulic tests of their pipes and fittings are to meet the requirements of Part VIII "Systems and Piping" of the MODU/FOP Rules.

2.9.2 In every MODU/FOP, provision is to be made for a pipeline to discharge bilge water of machinery spaces to reception facilities in accordance with 2.9.1. The pipeline is to be led to both sides of the ship.

In justified cases, on agreement with the Register, the pipeline may be led to one side of the MODU/FOP.

Discharge manifolds are to be located in places convenient for connection of hoses, to be fitted with standard discharge connections with flanges in accordance with Fig. 2.9.2 and to have distinguishing nameplates. The discharge manifolds are to be provided with blank flanges.

Close to the discharge manifolds, provision is to be made for the discharge observation and remote cut-off position or the effective communication system between the observation position and the discharge control position.

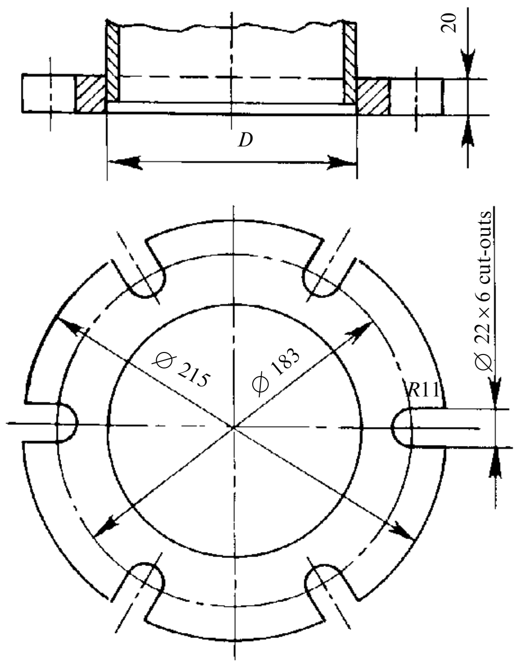


Fig. 2.9.2

N o t e. The flange is designed for pipes up to a maximum inner diameter of 125 mm and is to be of steel or other equivalent material having a flat face. This flange and its gasket of oil proof material are to be suitable for a working pressure of 0,6 MPa. The connection is carried out with six bolts of suitable length and of 20 mm in diameter.

2.10 HOLDING TANKS

2.10.1 General.

2.10.1.1 Any MODU/FOP is to be provided with a holding tank/tanks for collecting bilge water from machinery spaces capacity calculation of which shall be submitted to the Register for consideration.

2.10.1.2 The MODU/FOP with machinery installations burning heavy fuel oil of a relative density over 0,94 at 15 °C are to be provided with a holding tank/tanks for collecting and accumulating bilge water which are to be fitted with facilities for preheating oily mixture prior to the discharge of the tank/tanks contents to the sea through 15 ppm separator.

2.10.1.3 The customer-approved calculation of the total capacity of the holding tanks for oil residues regarding the regularity of their discharge to reception facilities or of their extermination in an incinerator is to be submitted to the Register.

2.10.1.4 If oil residues are discharged to reception facilities, the holding tank or tanks mentioned in 2.10.1.3 are to be provided with a special pump meeting the requirements of 2.10.1.5. Starting and stopping of the special pump is to be effected according to 2.9.2.

2.10.1.5 The pump used for the transfer of high-viscosity sludge is to be a self-priming displacement pump capable of dry friction operation and to have a discharge pressure not less than 0,4 MPa. In any case, the pump capacity is not to be less than 2 m^3/h. The discharge side of the pump is only to be connected to the pipe led to the deck, and also to the equipment of the sludge-burning incinerator, if any.

Inside the tank, the pump is to be placed not more than 3 m and 3,5 m above the suction pipe for the ships with the main engine output up to 15000 kW and over 15000 kW, respectively.

2.10.2 Requirements for holding tanks.

2.10.2.1 Holding tanks may be independent. The structural elements of holding tanks are to meet the requirements of Part II "Hull" of the MODU/FOP Rules.

2.10.2.2 The holding tank is to be fitted with:

.1 a manhole for inspection and cleaning;

.2 an air pipe;

.3 a heating arrangement if the tank is in contact with a medium or spaces with a negative temperature, or heavy fuel oil is used on board;

.4 visual and audible alarms actuated on 80 per cent tank filling.

2.10.2.3 The inner surfaces of a bottom and vertical walls of the oil residue tank excepting the built-in tanks as stated in 2.10.2.1, are to be smooth (external framing). In this case, the bottom is to be inclined towards a suction pipe.

2.11 INDUSTRIAL EQUIPMENT

2.11.1 The MODU/FOP industrial equipment used in drilling operations for exploration or exploitation of seabed mineral resources is not subject to the Register supervision.

3 REQUIREMENTS FOR EQUIPMENT AND ARRANGEMENTS FOR PREVENTION OF POLLUTION BY SEWAGE

3.1 APPLICATION

3.1.1 The requirements of this Section apply to the MODU and FOP equipment and arrangements intended for the prevention of pollution by sewage.

3.2 DEFINITIONS AND EXPLANATIONS

3.2.1 For the purpose of this Section, the following definitions have been adopted.

Holding tank means a tank used for the collection and storage of untreated sewage, activated sludge and pulp from a sewage treatment plant.

Sewage means:

drainage and other wastes from any form of toilets, urinals and WC scuppers;

drainage from wash basins, wash tubs and scuppers located in medical premises (dispensary, sick bay, etc.);

drainage from spaces containing living animals;

other waste waters when mixed with the drainages defined above.

Sewage treatment plant means a plant in which sewage is treated and disinfected.

Sanitary and domestic waste waters means:

drainage from wash basins, showers, laundries, wash tubs and scuppers;

drainage from sinks and equipment of galleys and other spaces annexed to galleys.

Number of persons on board means crew, passengers and special personnel, which the ship is certified to carry.

3.3 SCOPE OF SUPERVISION

3.3.1 General provisions for the procedure of supervision during manufacture of the equipment and arrangements intended for sewage treatment, and their surveys, as well as the requirements for the technical documentation on the whole ship submitted to the Register for examination are specified in the General Regulations for the Classification and Other Activity.

3.3.2 Subject to the supervision of the Register during manufacture are:

.1 sewage treatment plants with associated piping, pumps, electrical equipment, dosimeters, disinfection plants, control, regulation and monitoring devices;

.2 holding tanks with associated equipment, control, regulation and monitoring devices.

3.3.3 Subject to the Register supervision during assembly on board are:

.1 sewage treatment plants;

.2 holding tanks;

.3 pumps and discharge pipelines.

3.3.4 Prior to the beginning of manufacture, the following documentation on plants is to be submitted to the Register for examination:

.1 technical description and operating principle (no approval stamps are needed);

.2 general view drawings with sectional views (plant design, main dimensions, materials and coatings used);

.3 elementary electric diagram;

.4 diagrams of control, regulation, monitoring, signalling and protection;

.5 test program for prototype and series specimens.

3.4 SEWAGE TREATMENT PLANTS AND HOLDING TANKS

3.4.1 General.

3.4.1.1 One of the following types of equipment is to be installed on board the MODU and FOP:

.1 a sewage treatment plant and a holding tank. A single holding tank may be installed and used for collection of untreated sewage, activated sludge and pulp from the sewage treatment plant;

.2 holding tanks.

3.4.1.2 No discharge of comminuted and disinfected sewage, as well as of untreated sewage, is to be possible in areas where the discharge is prohibited.

3.4.1.3 Piping, electrical equipment and automation devices are to meet the requirements of Part VIII "Systems and Piping", Part X "Electrical Equipment" and Part XIV "Automation" of the MODU/FOP Rules.

3.4.2 Holding tanks.

3.4.2.1 The customer-agreed calculation of the total capacity of holding tanks regarding the area and mode of the ship's operation, and the number of persons on board is to be submitted to the Register.

3.4.2.2 The holding tanks may be built-in or independent. The structural elements of the holding tanks are to meet the requirements of Part II "Hull" of the MODU/FOP Rules.

3.4.2.3 The holding tanks are to be made of steel. The inner surfaces of the tanks are to be smooth (excepting built-in tanks), protected from contact with a medium, and to have a bottom inclined towards the outlet. The holding tanks are to be provided with manholes, and also with arrangements for flushing with water and for steaming. The use of arrangements for sewage agitation is recommended.

3.4.2.4 The holding tanks are to be separated by cofferdams from tanks used for drinking, washing and boiler water, and for vegetable oil, and also from accommodation, service (domestic) and cargo spaces. The holding tanks may be arranged without cofferdams in machinery and cargo spaces provided they are not intended for the carriage of edible raw material and provisions.

The holding tanks may be located in a separate space fitted with a mechanical exhaust ventilation.

3.4.2.5 The holding tanks are to be tested by a test pressure equal to 1,5 times the water column pressure measured from the tank bottom to the lower toilet bowl not provided with a shut-off device in the discharge line, but not less than 25 kPa.

3.4.3 Sewage treatment plants.

3.4.3.1 The capacity of the sewage treatment plant, in litres per day, is to be determined by the formula

$$Q = nq \qquad (3.4.3.1)$$

where

n = number of persons;

q = daily amount of sewage per one person, in l (according to the current standards).

3.4.3.2 The sewage treatment plant design is to ensure the reliable operation at an angle of 15° in any plane from a normal position. The design of electrical devices for control, alarm and protection of the sewage treatment plants and the elements used for manufacturing these devices are to be suitable for lengthy operation under vibration conditions at the following frequencies:

from 2 Hz to 13,2 Hz with an amplitude of ± 1 mm, and

from 13,2 Hz to 80 Hz with an acceleration amplitude of $\pm 0{,}7g$.

3.4.3.3 The sewage treatment plant and associated pumps, pipes and fittings which are in contact with sewage are to be reliably protected from its corrosive attack.

3.4.3.4 The sewage treatment plants are to ensure the level of purification in accordance with current international standards.

3.4.3.5 The sewage treatment plants are to be tested for tightness according to 3.4.2.5.

Pipelines are to be tested by a hydraulic test pressure $p_{test}=1,5p$, where p = working pressure.

3.4.3.6 The sewage treatment plants are to be tested at the manufacturer or on board the ship according to the Register-approved program.

3.4.3.7 The sewage treatment plants may be located in machinery spaces or in separate spaces with mechanical exhaust ventilation.

3.4.3.8 Effective means are to be provided for washing and disinfection of the sewage treatment plant, the associated machinery and piping, to carry out the work in connection with the inspection and repair of the plant.

3.4.3.9 Sewage pipes from ship's spaces scuppers to the sewage treatment plants and holding tanks are to be provided with arrangements preventing the permeation of untreated sewage smell into the ship's spaces.

3.5 ARRANGEMENTS FOR SEWAGE DISCHARGE

3.5.1 Two pumps are to be fitted for sewage discharge from the holding tanks.

Instead of one of the pumps an ejector may be fitted.

Having regard to the MODU/FOP purpose and service conditions, one pump (ejector) may be permitted on agreement with the Register.

3.5.2 Every MODU/FOP is to be provided with a pipeline for the discharge of sewage to reception facilities.

The pipeline is to be led to both sides of the MODU/FOP. In justified cases, on agreement with the Register, the pipeline may be led to one side. Discharge manifolds are to be located in places convenient for connection of hoses, to be fitted with standard discharge connections with flanges in accordance with Fig. 3.5.2 and to have distinguishing nameplates. The discharge manifolds are to be provided with blank flanges.

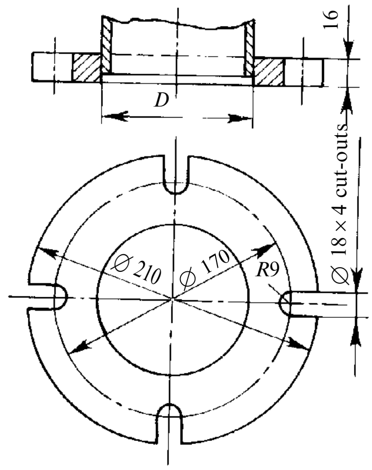


Fig. 3.5.2

N o t e . The flange is designed for pipes up to a maximum inner diameter of 100 mm and is to be of steel or other equivalent material having a flat face. This flange and its gasket are to be designed for a working pressure of 0,6 MPa. For ships having a moulded depth of 5 m or less, the inner diameter of the discharge connection may be 38 mm. The connection is carried out with four bolts of suitable length and of 16 mm in diameter.

Starting and stopping of the discharge are to be effected manually. Close to the discharge manifolds, provision is to be made for the discharge observation and remote cut-off position or for the effective communication system (telephone or radio system) between the observation position and the discharge control position.

3.6 INSTRUMENTATION

3.6.1 The holding tanks are to be provided with visual and audible alarms actuated on 80 per cent tank filling.

3.6.2 The sewage treatment plant is to be fitted with a device for treated and disinfected waters sampling.

4 REQUIREMENTS FOR EQUIPMENT AND ARRANGEMENTS FOR PREVENTION OF POLLUTION BY GARBAGE

4.1 APPLICATION

4.1.1 The requirements of this Section apply to the equipment and arrangements intended for the prevention of pollution by garbage.

4.2 DEFINITIONS AND EXPLANATIONS

4.2.1 For the purpose of this Part of the Rules the following definitions have been adopted.

Garbage means all kinds of victual, domestic and operational waste (excluding fresh fish and parts thereof) generated during the normal operation of the ship and liable to be disposed of continuously or periodically, except those substances, which are defined or listed in other Parts of the Rules.

Garbage incineration plant (incinerator) means a plant for reducing the volume and mass of garbage by means of incineration.

Garbage treatment plant means a plant for comminution and reduction of the garbage volume and mass.

Garbage container means containers and other receptacles for garbage collection.

Number of persons on board means crew, passengers and special personnel, which the ship is certified to carry.

4.3 SCOPE OF SUPERVISION

4.3.1 General provisions for the procedure of supervision during manufacture of the equipment and arrangements intended for garbage treatment and their survey, as well as the requirements for the technical documentation submitted to the Register are specified in the General Regulations for the Classification and Other Activity.

4.3.2 Subject to the Register technical supervision during manufacture are incinerators and garbage treatment plants with associated electrical equipment, control, regulation and monitoring devices.

4.3.3 Subject to the Register technical supervision during installation on board the ship are incinerators, garbage treatment plants and garbage containers.

4.3.4 Prior to the beginning of manufacture, the following documentation is to be submitted to the Register for examination:

4.3.4.1 incinerators:

.1 technical description and operating principle (no approval stamps are needed);

.2 general view drawings with sectional views (design, main dimensions, materials and coatings);

.3 drawings of burners;

.4 drawings of charger;

.5 diagram of the fuel system within the incinerator;

.6 elementary electric diagram;

.7 diagram of control, regulation, monitoring, alarm and protection;

.8 test program of prototype and series specimens;

4.3.4.2 garbage treatment and disposal arrangements:

.1 technical description and operating principle (no approval stamps are needed);

.2 general view drawings with sectional views (design, main dimensions, materials and coatings);

.3 elementary electric diagram;

.4 test program of prototype and series specimens;

4.3.4.3 detachable garbage containers:

.1 technical description (no approval stamps are needed);

.2 general view drawings with sectional views (design, main dimensions, materials and coatings);

.3 test program of prototype specimen.

4.4 EQUIPMENT FOR GARBAGE COLLECTION AND TREATMENT, AND INCINERATORS

4.4.1 General.

4.4.1.1 Every ship is to be provided with one of the following types of equipment for the prevention of pollution by garbage:

.1 garbage containers;

.2 garbage treatment and disposal arrangements;

.3 incinerators.

4.4.1.2 The garbage treatment plants and incinerators are to meet the requirements of Part VIII "Systems and Piping" and Part X "Electrical Equipment", and the control, regulation and monitoring devices are to meet the requirements of Part XIV "Automation" of the MODU/FOP Rules.

4.4.2 Garbage containers.

4.4.2.1 The garbage containers may be detachable or built in the ship's hull.

4.4.2.2 The customer-approved calculation of the total capacity of the garbage containers with regard to the intended area of navigation and service conditions of the ship and the number of persons on board is to be submitted to the Register.

4.4.2.3 The covers of discharge openings are to be fitted with a drive for their opening which ensures reliable operation under any service conditions of the ship.

4.4.2.4 The detachable garbage containers are to have smooth inner surfaces.

4.4.2.5 The detachable garbage containers are to be provided with fixtures for reliable securing on board the ship.

4.4.2.6 The garbage containers are to be provided with covers ensuring tight closure of openings for garbage loading.

4.4.2.7 As the garbage containers, separate receptacles (cans, barrels, buckets) may be used which are to be clearly marked to identify the type of garbage collected and are to differ in colour, shape, size or position.

4.4.2.8 The garbage containers referred to in 4.4.2.7 are to be located only in machinery spaces, a dining room, a messroom, accommodation and working spaces.

4.4.3 Arrangements for treatment and disposal of garbage into the sea.

4.4.3.1 The garbage comminutors are to provide for comminution of particles to a size not exceeding 25 mm.

4.4.3.2 The arrangements for disposal of garbage into the sea are to pass under the bulkhead deck and to be fitted with covers capable of being locked.

4.4.3.3 The arrangements for disposal of garbage into the sea are to be provided with the plates indicating the conditions of their use.

4.4.4 Incinerators.

4.4.4.1 These requirements apply to incinerators having a power up to 1500 kW.

4.4.4.2 The incinerators are to be designed and manufactured in accordance with the following requirements:

.1 the incinerators, except those designed for single charging are to be provided with a charging hopper the stop covers of which are interlocked to prevent their simultaneous opening;

.2 the incinerators designed for single charging are to have a charging hatch with an interlock to prevent its opening if the temperature in a combustion chamber during garbage incineration exceeds 220 °C;

.3 a caution plate or plates are to be attached to the incinerator, with instructions regarding the following:

.3.1 opening of combustion chamber doors during incinerator operation and recharging is prohibited;

.3.2 prior to starting the incinerator, ash and slag from combustion chambers are to be removed and openings for combustion air supply (if applicable) are to be cleaned;

.3.3 there is a restriction (if any) with regard to the amount of garbage to be loaded;

.4 the door of the ash box removing burnt matter is to be interlocked to prevent its opening when the combustion temperature exceeds 220 °C;

.5 the garbage loading system of the incinerator (if any) is to be designed so that the garbage being loaded is directed to a combustion chamber;

.6 provision is to be made for a peephole in the combustion chamber of the incinerators which is to be impenetrable for heat and flames;

.7 the incinerators design is to be such that the combustion process in the combustion chamber would occur at a negative pressure, which may be achieved by using a flue gas fan;

.8 the incinerator is to be designed for operation under the following temperature conditions:

.8.1 at the maximum flue gas temperature of 1200 °C at the combustion chamber outlet;

.8.2 at the minimum flue gas temperature of 850 °C at the combustion chamber outlet;

.8.3 at the preheating temperature of 650 °C in the combustion chamber;

.9 the incinerator is to be designed so that a temperature of 600 °C in the combustion chamber is reached within 5 min after starting;

.10 burners for fuel feeding are to have a design approved by the Register;

.11 on the pipeline feeding fuel to each burner, two solenoid control valves are to be mounted one after another which are to operate simultaneously. The incinerators equipped with several burners may have a valve mounted on the main fuel line and a valve mounted at each of the burners. For simultaneous operation, these valves are to be electrically connected in parallel;

.12 the burners are to have an interlock, which ensures liquid fuel feeding in the following cases:

.12.1 when the burner is in the operating condition;

.12.2 when combustion air is fed to the furnace;

.13 the incinerator is to be fitted with a device to control the burner flame, which is to include a sensor and the relevant equipment to shut down the incinerator in case of any of its elements malfunction;

.14 the flame control device is to automatically cut off liquid fuel feeding the burner within not more than 4 s in the following cases:

.14.1 loss of air flow to the furnace;

.14.2 flame failure in the torch;

.14.3 fuel pressure drop below the permissible working pressure;

.15 liquid fuel feeding the burner is also to be cut off when the fuel has not ignited within not more than 10 s since the moment of its supply;

.16 the incinerator is to be designed for one automatic restart only following the flame control device actuation in the absence of ignition, on flame failure or any component malfunction. Where this is not feasible, provision is to be made for a manual switch-over of the flame control device in order the restart might be possible;

.17 thermostatic devices like switches fitted in funnels as well as pyrostats regulated by means of an open bimetallic spiral are not allowed for controlling the burner flame;

.18 provision is to be made for cooling flue gases behind the incinerator to a temperature under 350 °C;

.19 a switch is to be fitted to the incinerator to enable its disconnection from all electrical power sources. This switch may be placed near the incinerator;

.20 where the incinerator is equipped with a flue gas fan, provision is to be made for starting the latter independently of other incinerator equipment;

.21 the incinerator control devices are to be designed so that any malfunction of the equipment would make further operation impossible and would cut off fuel feeding;

.22 a flue gas temperature control device with a sensor in an extraction duct is to be provided on the incinerator which is to cut off fuel supply to the burner if the flue gas temperature exceeds the value stipulated for the particular incinerator type;

.23 a temperature control device with a sensor in a combustion chamber is to be provided on the incinerator, which is to cut off fuel supply to the burner if the temperature in the combustion chamber exceeds the maximum permissible value;

.24 a negative pressure sensor is to be provided on the incinerator to control the draught and negative pressure in the combustion chamber which is to break the circuit of the burner routine relay before the negative pressure will rise to the atmospheric one. In this case, an alarm is to be activated;

.25 all the incinerator devices are to be designed for operation at the ship's heel of 15° either side under static conditions and 22,5° either side under dynamic conditions (rolling) with a simultaneous dynamic inclination of the ship (pitching) by 7,5° forward or aft;

.26 where fuel leakage is likely to occur, trays are to be fitted which are to be efficiently drained;

.27 detachable lockable containers secured against shifting are to be provided for the collection and storage of combustion products;

.28 the incinerator is to be provided with an opportunity to connect an audible alarm to a local alarm system and/or to the main machinery control room;

.29 light indicators showing components malfunction are to be provided on the incinerator. One indicator may be used for two or more components;

.30 the protection is to be designed so that in the event of the malfunction resulting in a shutdown associated with safety insurance it would be necessary to bring the incinerator back to the former condition manually;

.31 if electric ignition is provided for the incinerator, this is to be effected either by means of a high-voltage electric spark or a high-energy electric spark, or by means of an ignition coil;

.32 all rotating and moving mechanical and electrical components are to be protected against inadvertent touching;

.33 the control program for burners with automatic ignition is to ensure:

.33.1 preliminary blowing at least four air changes through the chamber(-s) and smoke uptake prior to ignition, but not less than during 15 s;

.33.2 blowing at least four air changes through the chamber(-s) and smoke uptake between starts, but not less than during 15 s;

.33.3 blow-through after fuel supply cut-off lasting for at least 15 s following fuel valves closure;

.34 the external surfaces of the combustion chamber are to be enclosed and insulated to the extent which prevents the exposure of the attending personnel to an increased temperature (more than 20 °C over the ambient air temperature) during normal operation. In areas of direct contact with the surfaces, the temperature therewith is not to exceed 60 °C;

.35 the incinerators with automated combustion process are to be fitted with protection and alarms on parameters given in Table 4.4.4.35;

.36 in respect of incinerators intended for burning liquid waste, provision is to be made to ensure safety of ignition and maintenance of burning process by means of, among other factors, an additional burner;

Table 4.4.4.35

Malfunction	Alarm	Automatic cut-off of fuel supply	Remarks
High temperature of exhaust gases	—	+	
High temperature in combustion chamber	—	+	
Shut-down of forced-draft fan	—	+	Additional auxiliary fan is also put into operation unless an exhaust fan is installed
Shut-down of exhaust fan	—	+	If installed
Heavy fuel oil temperature:			
High	+	—	Alternate operation of alarms for high-viscosity fuel
Low	+	—	
Low fuel oil pressure	—	+	Where a booster pump is necessary for normal operation
Ignition or flame failure	—	+	Each burner is to be fitted with an automatic isolating device
Cut-off of combustion air supply or low air pressure	—	+	
Automatic cut-off of fuel supply	+	—	

.37 the system of fuel supply to burners is to provide for an opportunity to shut them off from two positions one of which must be outside the space in which the incinerator is installed;

.38 the exhaust gas system of the incinerators is to meet the requirements of Part VIII "Systems and Piping" of the MODU/FOP Rules;

.39 the sludge incinerators are to include:

.39.1 incinerator proper or steam boiler, or heater of the thermal fluid system;

.39.2 burning installation;

.39.3 sludge processing system;

.39.4 filter;

.39.5 homogenization system;

.40 the sludge processing system is to include:

.40.1 tank for mixing oil residues with fuel oil;

.40.2 sludge preheating system;

.41 the homogenization system is to ensure processing the sludge into a homogeneous and combustible mixture. The system is to be put into operation following an adequate drainage of the tank. A device for continuous indication and monitoring of water content in the sludge is to be provided.

4.5 LOCATION OF EQUIPMENT AND ARRANGEMENTS

4.5.1 The detachable garbage containers are to be arranged on the open deck or in the ventilated spaces separated from accommodation and service spaces.

4.5.2 Garbage-pressing arrangements are to be installed in places large enough for the storage of garbage to be treated and for the maintenance of a technological process. The spaces are to be adjacent to the areas where domestic service and provision storerooms are located. The spaces are to be provided with freshwater flushing arrangements, coamings, scuppers, adequate ventilation facilities, and also with manual or automatic fire-fighting equipment.

4.5.3 The incinerators may be installed in machinery or separate spaces.

Where the incinerator is located in the machinery space, it is to be screened and arranged according to the requirements of Part VII "Machinery Installations and Machinery" of the MODU/FOP Rules. Where the incinerator is located in a separate space, the last is classified as "the Category A machinery space" according to Part VII "Machinery Installations and Machinery" of the MODU/FOP Rules.

4.5.4 Where the incinerator is located in a separate space, provision is to be made for:

.1 supply and exhaust ventilation ensuring sufficient air flow for operation of the plant;

.2 automatic fire alarm in accordance with Part VI "Fire Protection" of the MODU/FOP Rules;

.3 fire extinguishing system in accordance with Part VI "Fire Protection" of the MODU/FOP Rules.

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