

# RULES

FOR PLANNING AND EXECUTION  
OF MARINE OPERATIONS



Saint-Petersburg  
2010

Rules for Planning and Execution of Marine Operations of the Russian Maritime Register of Shipping have been approved in accordance with the established approval procedure and come into force since the date of publication.

These Rules have been compiled on the basis and instead of Part XVI "Marine Operations" of the Rules for the Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms (edition 2008).

The results of research and development activities R&D-2006 "Development of the Rules for Planning and Execution of Marine Operations" have been included in the text of the Rules.

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# **PART I. GENERAL**

## **1 APPLICATION**

**1.1** The requirements of these Rules for Planning and Execution of Marine Operations<sup>1</sup> apply to marine operations carried out during construction of offshore oil and gas field facilities or other structures and units covered by the technical supervision of the Russian Maritime Register of Shipping<sup>2</sup>.

**1.2** The requirements of these Rules do not apply to:  
works/operations which are traditional for shipping;  
laying of subsea pipelines and cables;  
installation of self-elevating units and semi-submersible units at a drilling site;  
transits of ships outside the prescribed areas of navigation (shall be carried out in accordance with the requirements of Section 8, Part II "Carrying out Classification Survey of Ships" of the Guidelines on Technical Supervision of Ships in Service with Annexes).

**1.3** On agreement with the Register, the requirements of these Rules can be extended to marine operations with the objects not covered by the Register technical supervision (e.g. towing/transportation of any large and heavy products if strengthening or any other alteration to the craft hull structure is required).

**1.4** The concepts of planning and execution of other types of marine operations not regulated by these Rules shall be submitted to the Register for review and agreement in each particular case. In this case, the information and documentation which allow to ascertain the efficiency and safety level of execution of the operations in question shall be submitted to the Register.

**1.5** Together with the requirements of these Rules the requirements of the Rules for Classification, Construction and Equipment of Mobile Offshore Drilling Units and Fixed Offshore Platforms<sup>3</sup>, the Rules for the Classification, Construction and Equipment of Floating Offshore Oil-and-Gas Production Units, the Rules for the Cargo-Handling Gear of Sea-Going Ships may be applied.

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<sup>1</sup>Hereinafter referred to as "the Rules".

<sup>2</sup>Hereinafter referred to as "the Register".

<sup>3</sup>Hereinafter referred to as "the MODU/FOP Rules".

## 2 DEFINITIONS AND EXPLANATIONS

**2.1** For the purpose of these Rules the following definitions have been adopted:

**Marine operations** are operations for assembly, transportation, mating and in-site installation of an object or its parts (blocks, tiers, columns, modules, positioning systems, etc.) carried out when the object or any of its parts are afloat or with the use of craft, and incorporating at least two of the stages listed. Two types of operations are distinguished:

**Shipyard operations afloat** are space-restricted marine operations conducted at an outfitting quay (pier) or within fully protected shipyard water area.

**Unrestricted marine operations** are space-unrestricted operations afloat conducted within a semi-protected water area or on high seas.

**Ballasting** is filling of ballast tanks or compartments.

**Block** is an independent specially fabricated component of an object.

**Towing** means transportation of a self-floating object or its part.

**Short term (Weather routed) towing** means the towing restricted by weather within the limits of a favourable weather forecast - good weather "window" (within 3 days).

**Unrestricted towing** means the towing unrestricted by weather or time.

**Module** is a structural component of the object consisting of blocks and which constitutes a transport unit or a functionally completed structure intended for transportation or mounting.

**Skidding/rolling** means the horizontal movement of an object on guides/rails by sliding/rolling.

**Object** is any large-sized and/or heavy-weight product, structure, assembly handled during marine operation.

**Positioning** is a marine operation necessary to maneuver and keep the object properly oriented and precisely located over a predetermined point of seabed.

**Recognized standards, reference documents, calculation and design methods** are existing national, industrial, departmental standards, reference documents and also calculation methods developed by separate organizations and authors, including foreign ones approved for application by authorized bodies or the Register.

**Engineering of a marine operation** means substantiation of all process procedures and support means (arrangements, appliances, instruments, machinery, tugs, etc.) necessary for execution thereof, which permit to safely achieve the set objective effectively, and at the minimum cost.

**A s s e m b l y** means any combination of components of the unfinished object.

**L a u n c h i n g** is the dynamic operation of the floating up of an assembly, block or module in a dry dock, immersion of a floating dock or a flo-flo type heavy-lift carrier, or after sliding from the slip or down the skid beams on a barge.

**M a t i n g** by float-on method is the vertical mating of tiers or components of a column or a substructure with a topside wherein the lower component submerges, but the upper component to be mated is floated over it and the whole assembly emerges.

**B u o y a n c y** pontoon (tower) is a watertight tank being temporary attached to the structure to ensure its buoyancy and stability during a marine operation.

**T r a n s p o r t a t i o n** is a marine operation involving movement of an object or its separate components from a construction site (place of manufacture) to the location of the next marine operation.

**I n s t a l l a t i o n** is a marine operation which includes the procedures for submersion (if necessary), positioning and fixing the object in accordance with the design (except for positioning of self-elevating MODU and semi-submerged MODU at a drilling location).

**T i e r** is an aggregate of horizontally joined blocks.

### **3 CATEGORIES OF MARINE OPERATIONS**

**3.1** Operations covered by these Rules include:

- launching of blocks, modules or objects;
- outfitting, assembly and horizontal mating of blocks afloat;
- lifting operations;
- rolling (skidding) operations;
- vertical mating of tiers by float-on method;
- vertical mating of substructure and topside by float-on method;
- transportation and towing (unrestricted or short-term) of the object or parts thereof;
- installation of the object on site.

**3.2** Depending on the risk level, marine operations are subdivided into the following categories (refer to Table 3.2):

Table 3.2

Category of operation	Risk description	Reference criteria
<b>1</b>	Simple operations	Lifting and mounting operations when the weight of the object being lifted is from 35 to 300 t
<b>2</b>	Well controlled operations or less weather-sensitive operations	Lifting and mounting operations in sheltered waters when the weight of the object being lifted exceeds 300 t Launching of the object in sheltered waters Short-term towing Transportation of the object on a specialized craft
<b>3</b>	Complicated operations or extremely weather-sensitive operations	Lifting and mounting operations on high seas when the weight of the object being lifted exceeds 300 t Mating of blocks afloat Rolling of the object on fixed or floating foundation. Unrestricted towing Launching of the object on high seas Installation of substructure on the seabed
<b>4</b>	Operation with high risk potential	Long-range ocean towing Erection of the topside as assembled

**3.3** Depending on the reference period, marine operations are subdivided into:

- weather-unrestricted operations with a reference period exceeding 72 h;
- weather-restricted operations with a reference period less than 72 h.

Marine operations with a reference period exceeding 72 h may be defined as weather-restricted if the operation can be interrupted during its execution and the object may be moved into a sheltered position when the operation criteria are exceeded.

Marine operations with reference periods less than 12 h are considered separately.

**3.4** Operation reference period  $T_R$  is determined by the formula:

$$T_R = T_{POP} + T_C \quad (3.4)$$

where  $T_{POP}$  = planned (design) operation period;

$T_C$  = estimated contingency time.

If the estimated contingency time  $T_C$  due to casual factors is not assessed, it may be taken equal to the planned operation period  $T_{POP}$  but not less than 6 h.

**3.5** For weather-restricted marine operations, the design environmental conditions may be established in each particular case in the technical design assignment, proceeding from the structural particulars of the object, technical



capabilities of supply vessels available, etc. The start of such operations is conditional upon existing acceptable weather conditions and their favourable forecast.

**3.6** Considering instability in weather conditions and inaccuracy in weather forecasts, the acceptable criteria of weather conditions (operation criteria) for actual beginning and performance of a marine operation shall be assumed less than the design criteria adopted. The operation criteria  $C_o$  for marine operation performance are determined by the formula:

$$C_o \leq \alpha C_D \quad (3.6)$$

where  $C_D$  = design criteria;

$\alpha$  = reduction factor taken equal to 0,8 for an averaged (anemometric) wind velocity; for wave heights – refer to Table 3.6.

Table 3.6

**Reduction factor  $\alpha$  for the seas**

Operation reference period $T_R$ , in h	Design wave height with 3 per cent probability of exceeding level, in m		
	$1,3 < h_{3\%} < 2,6$	$2,6 < h_{3\%} < 5,2$	$h_{3\%} > 5,2$
$< 12$	0,68	0,76	0,80
$12 \leq T_R < 24$	0,63	0,71	0,75
$24 \leq T_R < 48$	0,56	0,64	0,67
$48 \leq T_R < 72$	0,51	0,59	0,63

**3.7** For marine operations with the operation reference period exceeding 72 h, but which may be defined as weather-restricted, in establishing operation criteria the total duration of all separate stages shall be taken into account.

The operation criteria  $C_o$  for such operations shall be separately set in each particular case.

**3.8** Environmental criteria for weather-unrestricted operations afloat (exceeding 72 h) shall be based on extreme value statistics for a particular operation area. The operation criteria  $C_o$  for operation performance may be taken equal to the design criteria.

## 4 TECHNICAL DOCUMENTATION

**4.1** Prior to the performance of an operation, technical documentation which includes the operation plan and operation design shall be submitted to the Register for review and approval. For category 1 operations the operation plan shall be submitted, for other categories – the operation plan and operation design.

**4.2** The operation plan shall describe organization of the operation performance. The operation plan shall generally include the following sections:  
explanatory note;  
organization chart;  
operational schedule.

**4.3** The operation design shall describe details and procedure of the operation performance, craft, structures, arrangements and equipment involved. All essential aspects of the operation both for normal conditions of its performance and for potential critical situations shall be considered in the design.

The operation design shall generally include the following sections:  
description of external conditions and effects;  
restrictions due to external conditions;  
restrictions due to strength and stability of the object and the means and structures in use;  
navigational support and communications;  
operation performance guidelines;  
calculations;  
descriptions (drawings and specifications) of structures, assemblies and components;  
environmental protection.

**4.4** Operational sequence shall be developed for the planned/designed operations, and shall reflect characteristic environmental conditions, physical limitations, design assumptions and tolerances. The operational sequence shall be described in the Operation Performance Guidelines covering all aspect of the operation. Such Guidelines shall generally include:

distribution of responsibility among the participants of the operation;  
description of the handled objects, their overall dimensions, weight characteristics, centre of gravity (CoG) position, general view drawings;  
general arrangement/site plans;  
operational sequence/process and operation performance plan;  
contingency plans for contingency (when the standard procedure for marine operation is interrupted) and accident (when an accident is likely to occur) situations;  
permissible loading conditions;  
operational environmental criteria;  
permissible drafts, trim, heel and corresponding ballasting plans;  
description of systems and equipment, including their arrangement and operating manuals;  
list of ships and other craft involved;

- communication mode and systems;
- hydrometeorological support;
- life-saving appliances;
- reporting forms;
- list of verifications in preparation and performance of the operation;
- test plans;
- lists of spare parts, tools, accessories and emergency outfit.

Additional requirements for the manuals for particular types of marine operations are given in 4.10 to 4.15.

**4.5** As a part of the marine operation design, inspection and test programs, including instrumentation calibration procedures shall be developed. The results of inspections and tests shall be documented. For operations with high risk level, it is recommended to develop a common test program, which specifies the composition, sequence and procedure of inspections and tests for separate structures, equipment and systems. The program shall indicate controlled parameters, characteristics and their values in accordance with the design requirements.

**4.6** Limiting criteria for marine operation or parts thereof shall be clearly stated in the Operation Performance Guidelines.

**4.7** The documentation developed shall 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 shall ensure independent submission and review of drawings, procedure descriptions and calculations for all operation stages.

**4.8** If any actions in the course of marine operation are performed in accordance with the performer's standards (standard procedures), the above-mentioned documents shall be submitted to the Register for review and approval.

**4.9** The explanatory note shall include:

- design basis for marine operation;
- list of reference documents;
- marine operation stages;
- description of risk factors, risk management measures.

**4.10** Manuals for lifting operations, skidding/rolling operations and operations for securing the object during transportation shall include:

- operation procedure;
- arrangement plans of the handled objects prior to loading, description and calculations of ancillary equipment to be installed only to provide operations and/or securing;
- mooring and fendering systems layouts;

- arrangement plan of the objects on craft;
- grillage and seafastening arrangement plans, calculations and drawings
- global and local strength calculations for the object;
- global and local strength calculations for craft, measures for load distribution (if required) and hull strengthening (if required);
- calculations of trim, ballast (if required), stability, freeboard and unsinkability at all operation stages, including accident situations;
- contingency plan.

**4.10.1** Lifting (rigging) manual shall additionally include:

- selection of cargo handling gear, facilities and devices, their tactical and technical characteristics and specifications, crane capacity chart depending on the crane arm, layouts;
- slinging calculation.

**4.10.2** Skidding/rolling manual shall additionally include:

- characteristics of the equipment involved;
- trailers (multi wheel bogies) and hydraulic system layout;
- arrangement plan of traction equipment;
- strength calculation of cargo track;
- calculation of the object weight transfer process from support to support;
- seabed holding power calculation (if applicable).

**4.11** Launching manual shall include:

- description of launching method;
- launching appliances calculation;
- description and calculation of ancillary equipment for position-keeping after launching;
- methods and calculation of ballasting by means of solid and/or water ballast;
- stability, draft and unsinkability calculations including those in damaged condition.

**4.12** Feasibility of towing/transportation shall include:

- selection of craft, craft performance data, general arrangement plans, description of available standard systems, equipment and machinery and those to be installed additionally for marine operation, calibration tables of ballast tanks and piping and valve drawings;
- determination of towing resistance and required towing pull;
- selection of tow order vessels and tugs, performance data of tugs, general arrangement plans;
- description and calculation (if required) of towing arrangements, including emergency ones;
- selection of tow lines;

description of emergency outfit of the tugs;  
calculation of necessary reserves of fuel, lubricating oil and fresh water for performing a marine operation, including emergency reserve.

**4.13** Safe towing/transportation manual shall include:

planned route study;

places of refuge when hydrometeorological conditions get worse;

review of hydrometeorological situation on the route;

selection of favourable period for performance of a marine operation;

navigational hazards on the route;

transit schedule including calculations for proceeding to the places of refuge;

hydrometeorological support for a marine operation;

communications;

instruction to the towing/transportation manager (refer to 4.13.1);

instruction to the tug masters (refer to 4.13.2);

emergency plans (refer to 4.13.3).

**4.13.1** Instruction to the towing manager shall include, as a minimum, the following Sections:

**1** Introduction

**1.1** Tow route

**1.2** Ports of refuge

**1.3** Description of towed object and its basic seakeeping characteristics

**1.4** Safe towing conditions

**2** Organization chart of the personnel involved in the design, distribution of duties and responsibilities

**3** Preparation for towing

**4** Performance of towing

**5** Monitoring of the activities of the personnel involved in the design

**6** Provision of weather briefing and notices to mariners, selection of favourable towing courses and speeds

**7** Organization of supervision over the towed object condition

**8** Organization of full-time communication

**9** Management of activities at situations of all hands (where all the personnel and facilities available are put into use)

**10** Management of activities of the personnel involved in towing in all emergency situations (contingency situations that require an immediate response) and in distress.

**4.13.2** Instruction to the tug master shall include, as a minimum, the following Sections:

**1** Introduction

**1.1** Tow route

- 1.2 Ports of refuge
- 1.3 Description of the towed object and its sea-keeping characteristics
- 1.4 Safe towing conditions
- 2 Organization chart of the personnel involved in the design, distribution of duties and responsibilities
- 3 Preparation for towing
- 4 Performance of towing
- 5 Duties of the master during the preparation and performance of towing.
- 6 Organization of watch-keeping service, towing log-book form
- 7 Organization of all-hands jobs
- 8 Actions in emergency situations
- 9 Actions to prevent sea pollution
- 10 Measures to be taken in case of distress.
- 4.13.3 Emergency plans shall include in, as a minimum, the following Sections:
  - 1 General
  - 2 Organization chart of the personnel involved in the design, distribution of duties and responsibilities
  - 3 Damage Control Plan for the craft and towed object
    - 3.1 Preventive measures
    - 3.2 Measure to be taken in accident situations
      - 3.2.1 Flood control
      - 3.2.2 Fire-fighting
      - 3.2.3 Prevention of the object shifting (during transportation) or damage to its structures/attachment
      - 3.2.4 Navigation in heavy weather conditions
  - 4 Measures to be taken in case of any threat to human life
    - 4.1 Man overboard actions
    - 4.2 Actions to be taken in emergency medical situation
  - 5 Measures to be taken in case of the main tug failure
  - 6 Measures to be taken in case of the tow line breakage
  - 7 Measures to be taken in distress.
  - 4.14 Manual for installation and fixing of the object on site shall include:
    - exploratory design and seabed analysis;
    - description of the method and means of object positioning;
    - ballasting calculations for the object submergence and ballasting plan;
    - description of the object installation on the seabed or installation of the position-keeping system;
    - methods to control the accuracy of the designed installation on the seabed;

description of methods used for object securing on the seabed, selection of necessary means.

**4.15** Guidelines on the environmental protection during marine operation shall include:

- measures for pollution prevention and response;
- measures to be taken for limitation of emissions into atmosphere;
- measures to be taken for minimizing the effects on marine biota (totality of plant, animal and microorganism species combined by a common habitat) when the object is installed on the seabed.

**4.16** In cases where it is required by the Russian Federation legislation, the Contractor shall develop a works performance design in accordance with the requirements of the Russian regulatory documents. Designs for preparation of construction sites at sea, pile driving, seabed scouring protection and other underwater engineering works shall be developed and agreed in accordance with the standards, requirements and regulations which are in force in the hydraulic-engineering.

**4.17** The provisions of these Rules establish general requirements for the necessary amount of technical documentation while planning and execution of marine operations. Depending on the operation category, the amount of the technical documentation may be reduced. In well-grounded cases, the Register may demand increasing the amount of the documentation to be submitted.

**4.18** In cases where a marine operation stage is carried out within the Russian Federation's inland waterways, documentation relevant to the operation stage safety shall be submitted to the Russian River Register for review and approval at least 30 days before the planned entry into Russia's inland waterways.

## **5 ORGANIZATION OF TECHNICAL SUPERVISION**

**5.1** The Register technical supervision is carried out to confirm the compliance of the design, conditions and procedure for marine operations execution with these Rules. The Register technical supervision includes generally:

- review and approval of the marine operation design;
- checking of readiness for the operation performance;
- technical supervision in the course of operation under consideration.

The scope of the technical supervision – refer to Table 5.1. The operation is referred to a particular category upon receipt of the request for technical supervision.

Table 5.1

**Technical supervision of marine operations**

Operation category	Operation plan/ design review	Technical supervision during the operation execution	Documents to be issued
<b>1</b>	Availability of operation plan is checked	Appointment of the operation manager having necessary qualifications is checked	Report (Form 6.3.29) (readiness to perform the operation)
<b>2</b>	Availability and completeness of operation plan and operation design are checked. Towing design is approved	Availability of documents on readiness to perform the operation is checked	Conclusion letter; Report (Form 6.3.29) (readiness to perform the operation)
<b>3</b>	Availability and completeness of operation plan and operation design are checked. Operation Performance Guidelines and towing design are checked	Readiness to perform the operation is checked. Operation performance (except for towing/transportation stage) is monitored	Conclusion letter; Reports (Form 6.3.29) (readiness to perform the operation; operation execution)
<b>4</b>	Availability and completeness of operation plan and operation design are checked. Operation design is approved	Preparation and performance of the operation at all stages (except for towing/transportation stage) are monitored.	Ditto

The Register technical supervision does not substitute the monitoring the performance of marine operations by the designer, performer, warranty surveyor and owner of the object.

**5.2** Designs for category 3 and 4 marine operations are subject to review and approval by the Register Head Office (RHO) or the Register Branch Offices when duly authorized by RHO. Plans/designs for category 1 and 2 marine operations are subject to review and approval by the Register Branch Offices without RHO authorization. Applications for review of a marine operation design shall be sent to a relevant Register Branch Office or RHO Location, depending on the operation category.

The set of marine operation designs together with a covering letter and the full list of documents presented shall be submitted to the Register for review. On agreement with the Register, presentation of the design by separate parts may be allowed. In so doing, the explanatory note and organization chart of marine operation execution, as well as the full list of documentation to be developed shall be presented together with the first portion of documents taking into account the requirements and provisions of these Rules.



The documentation may be received from the developer in files and as hard copies. The approval procedure for the documentation received in files is dictated by the appropriate instructions of the RHO and Register Branch Offices. The hard copy documentation shall be submitted at least in two sets one of which after approval shall be handed over to the Register Branch Office which carries out technical supervision of the marine operation while the second portion of documents shall be kept in the Register archives as a control copy.

The marine operations designs shall be approved without any remarks. The approval is issued only upon canceling all the remarks by the designer.

**5.3** In the course of preparation for operation execution, the quality control plan (examination plan, book of presentation) with indication of the Register control points shall be agreed upon and persons responsible for its execution and maintaining shall be defined.

**5.4** At the stage of preparation for operation execution, the surveys shall be carried out, or the documents shall be verified to confirm the following:

- availability of approved operation plan and operation design;
- completion of construction of the objects or parts thereof;
- preparation of the object for operation, including installation of strengthening, buoyancy blocks and ancillary equipment;
- craft readiness;
- readiness of process equipment, mounting facilities and materials necessary to carry out an operation (for welding, gas or plasma cutting, bolt tightening, underwater engineering works, pile driving and securing, hydraulic testing, ballasting, etc.);
- manufacture, installation and testing of lifting arrangement and lifting appliances;
- manufacture and installation of arrangements, grillage for rolling, launching or transportation of the object;
- manufacture and installation of towing and mooring arrangements;
- readiness of positioning means;
- readiness of instrumentation and control system and non-destructive test equipment;
- personnel qualifications.

**5.5** In the course of marine operation execution, monitoring of operation performance shall be carried out. The results of monitoring shall be recorded in accordance with the control points in log books (plans, lists) or other documentation agreed with the performer. If the Register-approved design conditions of operation execution are violated, the causes of deviations shall be reviewed, an appropriate conclusion shall be made and the measures taken on their elimination shall be recorded. When it is needed, inspection of marine

operation execution conditions (determination of displacements, efforts, parameters of environmental conditions, etc.) is conducted using measuring equipment.

**5.6** At the stage of operation execution the following shall be monitored:

- environmental conditions of operation execution;
- object state and behaviour;
- adherence to the operation execution procedure;
- compliance of the operation execution results with the characteristics and values established in the design;
- intermediate acceptances of hidden work and essential structures (if applicable);
- non-destructive testing;
- maintaining of as-built documentation by the contractor.

**5.7** The Register representatives shall be provided with a possibility of being present during the most essential tests, monitoring of equipment and structural components to confirm the compliance of their parameters with the design, and also during the performance of the marine operation at large or its particular stages to evaluate the conformity of the permissible environmental conditions for the beginning and execution of the operation. The responsibility for providing access for the Register representatives is imposed upon the organization which has concluded an agreement with the Register on technical supervision of the marine operations.

**5.8** The technical documentation sets relating to the designs of marine operation execution shall be kept by the customer. In addition to the designs, the customer shall keep the reports and minutes of operation performance supervision. All necessary documents shall be available at any phase of operation execution.

## **PART II. GENERAL REQUIREMENTS**

### **1 BASIC PRINCIPLES OF MARINE OPERATION DEVELOPMENT**

#### **1.1 Subdivision of marine operations**

**1.1.1** The marine operations are subdivided into two basic groups:  
transportation;  
construction and assembly.

Both the transportation and the construction and assembly operations may be subdivided into constituent operations the special requirements for which are given in Part III "Special Requirements".

**1.1.2** The transportation operations include:  
transportation of the object on a craft;  
towing of the object;  
load in/out operations.

**1.1.3** The construction and assembly operations include:  
launching of the object at the yard water area;  
mating of objects or parts thereof afloat;  
installation of the object on site (except for installation of self-elevating and semi-submersible MODU at a drilling site).

**1.1.4** Installation of floating objects in the designed position may generally include the following number of individual operations:  
launching of the object under sea conditions from a ship/barge;  
upending;  
positioning;  
mating of the objects by float-on method;  
installation of position mooring system (except for installation of semi-submersible MODU at a drilling site).

**1.1.5** Installation of fixed seabed supported objects includes the following additional operations:  
submersion/emersion;  
righting up;  
ballasting;  
pile driving;  
penetration into the seabed and berm building-up.

**1.1.6** Other operations during object installation:  
connection of the object with other structures by means of hoses, cables and piping in the field facilities construction;

establishment of safety zones.

**1.1.7 Operations after object decommissioning:**

dismantling of the object position mooring system;

seabed scouring near substructure, pile cutting off;

removal of a part of solid ballast;

dismantling (if necessary) of a topside (entirely or by modules);

emersion of the object to a draft ensuring its transportation.

**1.2 Basic principles of marine operation planning and designing**

**1.2.1** Operations shall be planned/designed and performed regarding safety conditions.

**1.2.2** The safe conditions of marine operation performance afloat provide for the prevention of:

the threat to the personnel's life and health;

navigational hazard in adjacent area;

pollution and other environmental accidents;

losses and emergence of hazard for the structures of objects, ships and facilities involved in the operation.

**1.2.3** Operation planning/designing shall take into account potential contingency and accident situations. When such situation occurs, the object shall remain stable and under control.

**1.2.4** Planning/designing of marine operations shall provide the possibility of their performance under safe conditions or of their suspension when environmental design parameters are exceeded and other contingency and accident situations occur. If the operation afloat enters the phase when it cannot be suspended or terminated, such phases shall be subject to special consideration in the design and safe conditions for them shall be determined.

**1.2.5** The design of marine operations shall be based, as rule, on approved principles, technology, systems and equipment. All potential contingency situations shall be reviewed during the design and the relevant action plans shall be developed. Such plans shall include a list of additional spare (consumable) equipment on board the object and supply vessels, the activities of the support personnel, the descriptions of procedures for hazard prevention, etc.

**1.2.6** The planning/designing shall be carried out by the competent bodies recognized by the Register.

**1.2.7** The design, organization and performance of marine operations shall be carried out in accordance with the provisions of these Rules, and also with the recognized calculation methods, norms, standards (national and international) and reference documents approved by the Register. Use of the other, more effective calculation methods and technical approaches is permitted provided they ensure required safety level set by these Rules. All additional

standards, norms and methods shall be submitted to the Register for review and agreement.

**1.2.8** 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 the environmental conditions;

- general planning of the operation including establishment of the basic principles of operation performance, equipment needed, economic factors, etc;

- definition of the environmental conditions and restrictions acceptable for operation performance;

- brief description of actions in operation performance;

- execution of calculations and engineering developments;

- development of the Operation Performance Guidelines.

**1.2.9** The composition of design basis and output documentation shall be determined at the early stages of design. The definition of environmental conditions and restrictions, as well as brief design descriptions shall ensure a general basis for the design of the operation, and also give a clear insight into all the stages of the marine operation performance and monitoring. The description of environmental conditions shall include basic parameters, characteristic conditions, design loads and reactions, load combinations, etc. The brief design descriptions shall contain planned and controlled actions, calculation, simulation<sup>1</sup> and design methods used, initial specifications, accepted criteria, etc.

**1.2.10** The organization chart of operation performance shall describe distribution of responsibility among the persons involved in the operation and the functional duties of the key personnel.

## **2 ULTIMATE STATES IN MARINE OPERATIONS**

**2.1** The performance of a marine operation on object transportation, positioning or installation is unsafe or prohibitive if the efforts in the object or transport craft structure, securing system, towing line or the displacements of the object and supply vessels reach the relevant ultimate states.

Conducting marine operations, the following kinds of dangerous states of structures, arrangements and equipment of the object, transport craft and supply vessels shall be prevented:

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<sup>1</sup>Requirements for the calculations and model tests of the object launching, tilting, floatation and setting down on the seabed are given in Appendix 2.

excessive material deformations affecting operability;  
loss of structure form stability;  
formation of fatigue cracks;  
brittle failures;  
breakages of ropes, chains and other connecting elements.

**2.2** During performance of marine operations the following are considered as ultimate states:

the first (basic) ultimate state corresponding to the formation of breaking forces in the structure of the object, in its securing system, anchor, mooring arrangements and bumpers, and also the impermissible displacements of the object and supply vessels 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 do not cause any damages or grave disruptions of normal conditions of the marine operation, but are borderline for the normal operating conditions;

emergency ultimate state corresponding to the damage (destruction) of any main component of the structure or its securing system;

in case of unrestricted marine operation and provided that the number of design loadings in the operation may reach or exceed several thousand cycles, the fatigue ultimate state wherein the braking forces corresponding to the first (basic) ultimate state are determined with due regard to fatigue conditions in the structural components of the object (securing system), shall be additionally considered taking into account the cyclic loads.

**2.3** When a marine operation is designed, all the above-mentioned ultimate states, except for fatigue one which is taken into account if necessary, shall be considered.

It is necessary to observe the conditions that preclude the onset of the ultimate states in question specified in Chapter 2.4, Part II "Hull" of the MODU/FOP Rules or in the relevant Chapters of Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships.

### **3 ENVIRONMENTAL CONDITIONS, WEATHER FORECAST, INVESTIGATIONS**

**3.1** For marine operations afloat, the design recurrence of external effects is established in each particular case proceeding from the operation duration having regard to the operation area, season and potential consequences of exceeding the assumed design parameters of the effects.

**3.2** For the operations afloat or their separate stages of a short-term duration (less than 72 h) defined as weather-restricted, the design values of external effects may be assumed proceeding from the actual technical capabilities of ships and equipment in use taking into account a specific weather forecast.

**3.3** When establishing the design environmental conditions, their seasonal variations shall be taken into account. The design parameters shall 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 in the generalized statistics shall be taken into account, namely: tide variations, wave and wind conditions, current variations. Sailing directions, harbour regulations, etc. shall be sources for such information.

**3.4** When developing the design of a marine operation, all environmental conditions which may affect its performance shall be 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 (seabed topography, sea depth, water area dimensions) and geological conditions at the object installation area. If necessary, seismic effects during the object installation (until it is secured in a designed position) may also be considered.

The parameters of external conditions shall be assumed for the immediate areas of marine operation performance.

Description, parameters and external effects calculation methods are given in 2.2, Part II "Hull" and in 2.5, Part IV "Stability" of the MODU/FOP Rules.

**3.5** The design parameters of environmental conditions shall normally be adopted on the basis of generally recognized and reliable observed data of sufficient duration and investigations related to the area in question. The observed data over 3 to 4 years period, as a minimum, shall be used. If the data for a specific area under consideration are unavailable, the environmental conditions parameters may be established on the basis of calculations according to the methods recognized by the Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet). The information on collection and origin of environmental conditions data shall be submitted to the Register for review and approval.

**3.6** In order to describe environmental conditions, the generally accepted parameters used in determination of external effects, loads and structure reactions shall be applied. When describing external effects of casual character, long and short-term statistics shall be used. Special emphasis shall be placed on the assessment of reliability of statistical techniques and their results. The long-term (condition) functions of variation in such environmental conditions as wind, waves, currents, etc. shall be primarily described by certain statistical

distributions. When evaluating extreme values of external effect parameters, the recognized extrapolation techniques may be used.

**3.7** The design parameters of environmental conditions, statistical distributions of their values and directions adopted in the design of marine operations shall be submitted to the Register for review and approval.

**3.8** The scope and composition of investigations in the areas of marine operations associated with essential change of the structure draft (mating by float-on method, upending, installation on the seabed) are adopted in accordance with the type, dimensions, importance of the object and available information on environmental, including geological, hydrographic and other conditions in the areas under consideration. The selection of techniques and the range of investigations shall be compatible with environmental conditions of the area in question. When selecting the range of investigations, the following shall be taken into account:

- errors in positioning of craft used for investigations;
- errors of navigation equipment used in performance of marine operations;
- possible deviations of the object during the performance of marine operations under actual conditions.

**3.9** The results of investigations shall be submitted to the Register for review. Such reports shall include:

- information on the time of investigation and on the performer;
- comprehensive description of the equipment used and of the procedure of field and laboratory studies;
- investigation results;
- evaluation of the errors and restrictions in application of investigation results.

**3.10** The topographic survey of the seabed shall be conducted at the object installation site.

Depth-sounding accuracy at the object installation area shall 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 shall be placed on potential seabed movements. In addition to the generally accepted depth-sounding techniques, it is recommended to scan the seabed with a multibeam echosounder or other similar device in areas of potential underwater obstructions (boulders, anchors, debris, etc.).

**3.11** Geological investigations are conducted for the immediate area of the object installation. The scope and composition of geological investigations at the object installation site may be determined on the basis of the documents of the object general design as its amount of information exceeds required minimum for marine operation performance. The investigation documents shall



contain data obtained from the field and laboratory investigations of the seabed as well as geotechnical sections with data on bedding of soils and design values of their physical and mechanical properties. Particular attention shall be given to geological conditions needed for evaluation of the holding capacity of piles and ship anchors or the anchors of roads facilities during the object positioning. The results of detailed geological investigations may also be required while handling the problems of the object installation, in particular, for setting down the object on the seabed. Seabed properties shall be defined for planned anchorages during the operation.

**3.12** The marine operation design shall include arrangements for receiving weather forecasts prior to and during the operation. Such weather forecasts shall be based on reliable sources and shall consider the nature and duration of the planned operation. The weather forecast shall be in writing.

In addition to the general description of the weather situation and its predicted development, the weather forecast shall include:

- wind velocity and direction;

- height, mean and maximum period and direction of wind and long-period waves;

- information on precipitations, lighting, ice conditions, etc.;

- data on sea level variations (tide variations, storm surges, etc.);

- visibility;

- temperature;

- barometric pressure.

The listed parameters shall be predicted for a period of 12, 24, 48 and 72 h. A forecast for several days shall also be provided.

Special emphasis in weather forecasts shall be placed on the accuracy and reliability of determination of such predictable parameters as average wind velocity, wave parameters (height and period).

The weather forecast shall take into account the worst scenario of weather conditions development. This is of primary importance for areas with unstable 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.

**3.13** Depending on the extent to which the performance of different types 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 substructure with an object topside on high seas, long-range ocean towing under heavy environmental conditions, positioning and installation of the object (category 4 operations).

Level B covers weather sensitive operations the violation of which may result in significant financial losses. Among these are launching or mounting operations on high seas, long-term towing, etc. (category 3 operations).

Level C covers operations less sensitive to weather conditions and operations carried out on a regular basis. Among these are shipyard operations: lifting and mounting operations when the object weight does not exceed 300 t, towing in sheltered waters and others (category 1 and 2 operations).

**3.14** Depending on the prediction level, the weather forecasts shall meet the requirements of Table 3.14.

Table 3.14

Weather Forecast Levels			
Weather Forecast Level	Is availability of environmental conditions data for the operation performance needed?	Number of the independent weather forecast sources	Maximum weather forecast interval, in h.
A	Yes	2	4 <sup>1</sup>
B	No <sup>2</sup>	2 <sup>3</sup>	4
C	No	1	12
<sup>1</sup> Smaller intervals may be required for the operations most sensitive to weather conditions. <sup>2</sup> The need for hydrometeorological data for the particular operation site is considered and determined separately in each particular case. <sup>3</sup> When properly justified, the weather forecast may be based on one source only.			

**3.15** For marine operations particularly sensitive for certain environmental conditions such as waves, swell, current, tide etc., systematically monitoring of these conditions prior to and during the operation shall be arranged. Monitoring shall be systematic. Responsibilities, monitoring methods and intervals shall be described in a procedure. Essential monitoring system shall have back up systems. Predicted variations of these parameters during execution of the marine operations shall be based on monitored variations, tabulated values and forecasted variations. Any unforeseen monitoring results shall be reported without delay.

Tidal variations shall additionally be monitored a period with the same lunar phase as for the planned operation.

## 4 ORGANIZATION AND MANAGEMENT OF MARINE OPERATIONS

**4.1** Marine operations shall be conducted in accordance with the plan and design developed as a part of the structure design or with the independent

design approved by the Register and also with due regard to good seamanship that prevents unnecessary risk. The responsibility for the observance of necessary conditions, rules and requirements of the marine operation design rests with the operation manager.

**4.2** The design/plan of marine operation shall describe in detail organization of the operation execution and establish responsibility of the key personnel involved in the marine operation, and in possible emergency and accident situations.

**4.3** The organizations involved in the operation (designers, performers) shall have necessary licenses and certificates in accordance with the existing legislation. The organizations shall comply with the general requirements listed in Section 7 and the requirements of 8.2, Part I "General Regulations for Technical Supervision" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

**4.4** The operation manager and personnel involved in the operation shall possess adequate qualification and competence, have an appropriate experience and knowledge within the area of their responsibility.

**4.5** The representatives of the supervisory organizations and state supervision bodies shall familiarize themselves with all aspects of the planned operations and possess a thorough knowledge with respect to limitations and assumptions for the design. A briefing regarding responsibility, communication, work procedures, safety, etc. shall be performed for the representatives of the supervisory organizations and state supervision bodies.

**4.6** For operations with a planned duration exceeding 12 h the work of the personnel shall be arranged in several shifts and an appropriate number and composition of the personnel shall be provided.

**4.7** Particular emphasis shall be placed on ensuring reliable communication in organization of a marine operation. Communication lines, primary and secondary means of communication shall be clearly defined in the special section of the marine operation design. The planned flow of information, a communication language, etc. shall be also presented in the design.

**4.8** In the course of a marine operation, the direct designer's supervision shall be carried out or a procedure for the designer's prompt approval of the results of essential work performance during the operation and agreement of alterations to be made shall be established. A procedure for amending the plan and design which ensures agreement with the parties concerned and informing the participants shall be established.

**4.9** Prior to a marine operation all craft, structures, equipment, systems, instrumentation used during a marine operation shall be inspected, calibrated and tested in accordance with the design and existing standards. Both primary

and secondary structures, equipment, systems, components and assemblies shall be tested.

**4.10** The control over the operational procedure shall be carried out in compliance with the Quality Control Plan which defines points, scope and methods of control for all the participants in the operation, as well as the supervisory organizations and supervision bodies.

**4.11** The actual conditions of particular marine operation performance afloat shall not be different from the conditions specified in the design of relevant operations.

**4.12** The preparation and step-by-step execution of a marine operation shall be recorded. It is recommended to include model forms of the relevant reports into the Operation Performance Guidelines.

## **5 ENVIRONMENTAL PROTECTION**

### **5.1 General**

**5.1.1** Protection of the environment during marine operations execution shall be ensured through the development and implementation of a set of measures and arrangements aimed at mitigation and prevention of unfavourable impact on the environment in compliance with the provisions of the International Convention for Prevention of Pollution from Ships (MARPOL 73/78) and the Annexes I to VI thereto and the Guidelines on the Application of Provisions of the International Convention MARPOL 73/78.

**5.1.2** Within the inland waters, territorial sea, on continental shelf and in the exclusive economic zone of the Russian Federation the marine operations shall be performed meeting the environmental protection requirements in compliance with the Federal Law "On Environmental Protection", other normative legal acts of the Russian Federation and subjects of the Russian Federation.

**5.1.3** Due account shall be taken of the environmental limitations for the marine operation area.

**5.1.4** The environmental protection arrangements shall include:

- organizational arrangements;
- measures to prevent marine environment pollution;
- measures to limit air pollution;
- measures to mitigate impact on the marine biota;
- engineering and environmental monitoring;
- development of the marine pollution emergency response plans,

**5.1.5** Organizations involved in preparation of the objects and craft for a marine operation are responsible for observing the decisions relevant to the

environmental protection made in the design, as well as for observing the national legislation and international environmental agreements.

**5.1.6** Regulations, procedures and policy of the object owner in the field of environmental protection shall be brought to the notice of the whole personnel involved in the marine operation.

**5.1.7** All violations of standards and regulations, as well as deviations from marine operation procedure, which may be considered as potential sources of environmental risk, shall be recorded.

**5.1.8** The marine operation manager is responsible for the fulfillment of the requirements of these Rules concerning health, safety and environment protection (HSE).

**5.1.9** The personnel responsible for the environmental protection solves the following tasks:

- implementation of the environmental actions in accordance with the agreed HSE plan;

- preparation and submission of statistical reporting;

- preparation and submission of data on payments for resource exploitation, discharges and emissions;

- sampling on the object site and at places agreed upon with the environmental authorities within the framework of a long-term program;

- sample analysis, data preparation and submission;

- environmental protection personnel training.

## **5.2 Basic activities aimed at environmental impact mitigation**

**5.2.1** Organizational arrangements include:

- checking availability of ship's documents on environmental protection;

- availability of the oil pollution emergency plan and garbage management plan;

- checking of the technical facilities designed for the prevention of oil, sewage and garbage pollution, as well as air pollution;

- ensuring of oil, oily and sewage water, and garbage intake from craft used in marine operations;

- establishment of a procedure for handling the industrial waste;

- briefing and examination of crew members and personnel involved in marine operations regarding environmental protection.

**5.2.2** Measures to prevent marine environment pollution shall include:

- regular examinations and maintenance of pumps, machinery, piping, shut-off fittings and hoses;

- installation of coamings and drip trays to prevent spillages;

- observation of safety measures during pumping, intake/discharge of fuel, bilge and sewage waters, storage and discharge of oily waste and garbage.

**5.2.3** Measure to limit air pollution may include:

- use of low-sulphur fuels, catalysts and filters;
- fine adjustment of engines and boilers;
- use of antismoke fuel additives;
- installation of silencers and spark arresters of exhaust gas pipes and uptakes;
- installation of filters in smoke ventilation and ventilation systems, timely cleaning and replacement thereof.

**5.2.4** Impacts on marine biota occur during installation of supporting structures and anchors on the seabed, performance of underwater engineering works, as well as during anchoring of auxiliary vessels and manifest themselves in the following:

- increase in water turbidity due to rise of the near-bottom suspended matter and seabed moving;
- transition of the harmful contaminants which are a constituent part of long-term sedimentation into a dissolved state;
- forced migration of fish, marine mammals and birds from the working area caused by the presence of the object, craft and personnel and associated with noise, sea water movement, artificial lighting, emission of environmentally harmful substances.

**5.2.5** Measures to mitigate impact on marine biota shall provide for;

- selection of environmentally safe period throughout a year for execution of marine operations and lay out of safe towing/transportation routes;
- prohibition of work performance and craft movement in areas not stipulated by the marine operation design;
- exclusion, in general, of explosive works (underwater seabed ripping and other underwater engineering works are permitted to be performed by explosive method only if the construction management plan includes a feasibility study which excludes the possibility of performing these works by any other methods).

**5.2.6** Engineering and environmental monitoring shall ensure:

- measurements, monitoring and control over the emissions of contaminants to atmosphere and discharges of untreated sewage into marine environment from the object and craft;
- monitoring the established indicators of water content and properties at the border of processing discharge zone of the water area adjacent to the object;
- waste storage monitoring on-site;
- check for compliance with the standards for ultimate discharges and emissions.

**5.2.7** Emergency response measures shall include:

availability of the oil-pollution emergency plan approved in accordance with the established procedure;

logistic support and maintenance of personnel and facilities ready for emergency response or conclusion of an agreement with a specialized organization.

**5.2.8** To reduce the amount of waste provision shall be made for repeated use of water during bore cleaning and hydraulic testing of process piping. Water displaced from the pipeline shall not be discharged into the sea without pre-cleaning.

**5.2.9** Incoming inspection of engineering structures and materials shall establish conformity of material quality to the design in respect of the content of toxic substances hazardous to marine biota.

## **6 NAVIGATIONAL SAFETY OF MARINE OPERATIONS**

### **6.1 Navigational safety during towing/transportation**

**6.1.1** Navigational safety of a marine operation is achieved through adequate operation management, proper organization of watch keeping and communication, thorough preparation for transit at sea and/or through inland waterways, regular receipt of navigational information by radio in the form of NAVAREA warnings in accordance with the World-Wide Navigational Warning Service, NAVIP navigational warnings concerning the information not included in NAVAREA, PRIP (COASTAL WARNINGS) in accordance with the regional systems of navigational warnings and LOCAL WARNINGS for harbour water areas, receipt of navigational information through publications (Notices to Mariners of the Head Department of Navigation and Oceanography of the Ministry of Defence of the Russian Federation and hydrographic offices of fleets) and weather forecasts, through uninterrupted operation of electrical and radionavigational devices, as well as compliance with the requirements of Annex 28 "Guidelines for Safe Ocean Towing" to the Guidelines on Technical Supervision of Ships in Service and due to compliance with the requirements/regulations of good seamanship.

**6.1.2** Preparation for marine operation includes:

completing of the established ship folio with nautical charts, manuals and nautical publications;

receipt of materials for updating the ship folio;

selection of nautical charts, manuals and nautical publications for the scheduled transit, updating thereof;

preparation of navigational systems and equipment and, if necessary, repair thereof, replenishment of spare parts and tools, determination (testing) their parameters and corrections;

receipt of information on mine, ice and hydrometeorological situation (if necessary, conclusion of an agreement on hydrometeorological center(s) pilotage;

study of navigation area, route selection and route planning – input of route points and other navigational information into the receivers of the global navigation satellite system (GNSS) and radionavigation system;

study of the selected transit route with officers;

checking availability of information on ship's maneuvering characteristics;

checking of general alarm system operability, expiring dates of pyrotechnic signal means.

**6.1.3** When studying the area of unrestricted marine operation, the following shall be taken into account:

general navigational-hydrographical characteristic of the area, remoteness from shore, presence of navigational hazards, seabed topography and depth, presence of shoals, distinguishing depths and their proximity to the planned route;

hydrometeorological features: prevailing winds, cyclone paths, wave conditions, probability of reduced visibility, ice conditions and limits of floating ice and icebergs, possible icing areas, active currents;

availability of radionavigation systems, the receivers of which are provided for the participants of marine operations, their operating modes, accuracy, possible restrictions on use;

pilotage restrictions recommended by hydrometeorological centers (wave height, wind velocity, wave direction, etc.);

broadcasting for different areas of navigation the weather forecasts, storm and ice warnings, navigational information.

**6.1.4** When studying an area with restricted navigation conditions and port approaches, the following shall be considered additionally:

navigational and hydrographic features of the area: recommended paths and routes, fairways and channels, length and width of their tracks; hazardous and forbidden zones, zones prohibited for navigation and restricted areas of navigation, areas of heavy ship and ferry traffic, fishing, development and production of oil and gas; traffic separation schemes; possible anchorage and characteristics thereof;

hydrological features: tidal and surging phenomena; characteristics and degree of wind waves; water desalination; influence of all these factors on allowable draft and speed when passing through shallow waters;



occurrence of heave of sea;

availability of navigational equipment in the navigation area, operating mode and restrictions on use of the equipment; the applicability of radars for positioning of the ship; distinctive signs to identify navigational references and warning markers;

possible methods and necessary frequency of positioning in order to be kept within the limits of fairways or channels;

zone of operation, types of maintenance of the Vessel Traffic Service (VTS);

local regulations applied in ports and areas constrained by navigation conditions.

**6.1.5** When preparing passage through the most difficult areas, it is necessary to resort to mathematic simulation, modeling on simulator or testing in model basin.

**6.1.6** After studying the navigation areas, the manager of this phase of a marine operation together with the tug(s) master(s) shall select the transit route by the general nautical chart(s) dividing the entire route into sections depending on situation and hydrometeorological conditions, shall plan arrangements to ensure safety of navigation. Route planning shall be made on small and large-scale navigational charts of a scale which is the most favourable for the area concerned. In so doing, the information from large-scale charts and plans, which may contain important navigation data, shall be used. Study of transit through the RF inland waterways shall be performed using the Atlas of the Unified Deep Water System of Russia.

**6.1.7** Simultaneously with route planning, preparation of the small and large-scale navigational charts and plans shall be carried out. If necessary, safety contour shall be plotted and isolated dangers shall be defined; the visibility range of lighthouses and signs (taking into account the height of observer's eye) and lighting intensity shall be marked, the lighthouse sectors indicating the hazards, boundaries of zones prohibited for navigation, zone of operation the VTS shall be more clearly defined. When planning the route, the course at safe distances from the navigational hazards shall be plotted, and wheel over points and, if the chart scale permits, wheel over starting and end points shall be marked, check bearings to selected reference points and/or distances thereto shall be measured and plotted; beams and control four-point-bearings shall be marked. When the alterations of course are frequent, the length of each route section shall be measured and indicated at the beginning of the section, duration of the route on each section at designed speed shall be calculated and indicated on the same section.

On sections where the ship's course runs close to the hazards, it is preferable to plot the safety isolines of the navigational parameters on the chart. The wheel over points of the route planning, boundaries of fairways, of hazardous and forbidden zones, allowable cross-track deviations from the selected track and from the wheel over points, coordinates of the reference points and other necessary information shall be input into the receivers of GNSS and radionavigation system.

**6.1.8** When the equipment is rendered operative, its technical parameters shall be checked. The equipment is considered operative, if its operating parameters comply with the manufacturer's specification. The navigational equipment operability shall be checked as follows:

- for gyrocompass – by steadiness of landmark bearings if it was not switched off during the ship's anchorage;

- for GNSS receiver – by availability of indication of last observations data;

- for a radionavigation system receiver - by steadiness of the navigational parameter readings.

**6.1.9** Printers shall be subject to checking for the availability of paper, toggle switches of sensors and printing types shall be switched on, verification printout shall be made, selected print interval for the port waters shall be set. Moreover, time readings of the reverse recorder shall be set, verification printout shall be made, time shall be marked on the course recorder. Echo sounder shall be subjected to checking for the availability of paper and, if necessary, depth alarm shall be installed. Information sensors of the navigation system or videoplotter shall be selected. The automatic alarm for traffic ship monitoring shall be activated.

**6.1.10** Watch keeping shall be so organized as to ensure reliable safety of navigation. Throughout the passage, the watch-keeping personnel shall meet actual navigational conditions and circumstances. When appointing the watch-keeping personnel, the following shall be taken into consideration:

- ensuring of continuous watch;

- weather conditions, visibility, day time;

- navigation area characteristics, including vicinity of navigational hazards, traffic density, possible presence of small craft with poor discernibility, high-speed craft, ferries, etc, which require discharge of specific duties by the watch officer;

- possibility and practicability of using the shipboard navigational equipment, and technical condition thereof;

- any other requirements for watch keeping stipulated by special operating conditions.

**6.1.11** Watch keeping shall be so staffed that its efficiency is not reduced due to the tiredness of its individual members. Navigators shall be given clear instructions: in which situations the master shall be called without delay onto the bridge.

In the course of everyday work, the watch officer shall gain the ability to report the current information in time, precisely and briefly. The master shall encourage in every possible way the watch officer to learn the following regulation: in case of any threat to the tug, people and object, the propulsion plant, steering gear and signalling devices are at his full disposal. However, whenever possible, the watch engineer shall be notified in time of the intention to change the operating mode of the propulsion plant.

## **6.2 Navigational safety at the installation site**

**6.2.1** The object owner is obliged to inform Head Department of Navigation and Oceanography of the Ministry of Defence of the Russian Federation for publication in the Notices to Mariners:

not later than 120 days in advance – about commencement of installation and dismantling works;

immediately – about commencement and completion of works, as well as about the results of inspection at the installation site after dismantling, with the reports enclosed.

**6.2.2** At the work performance area a safety zone extending over 500 m from the outer edge of the object shall be established.

**6.2.3** If the primary warning alarm and navigational equipment of the object are inoperative, the work performance area shall be provided with IALA<sup>1</sup> buoyage, Region A, and secondary warning alarm and navigational equipment shall be installed on the object. The composition and characteristics of the secondary warning alarm and navigational equipment shall be defined by the Hydrographical Services of the Fleet on the basis of materials presented by the organization qualified for installation of the object.

**6.2.4** To designate the existing underwater dangers, it is recommended for the time of work performance to deploy buoys fitted with visual alarm and radar reflectors.

**6.2.5** For operations performed at the installation site, the organization chart of marine operation shall provide for monitoring center for navigation situation in the work performance area, located on one of the craft involved in the operation.

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<sup>1</sup>The International Association of Marine Aids to Navigation and Lighthouse Authorities formerly called the International Association of Lighthouse Authorities (IALA) adopted in 1980. The IALA defines one system of marks specifying the shapes, colours and characteristic lights of buoys depending on their purpose.

## **7 REQUIREMENTS FOR STRUCTURES, SYSTEMS AND EQUIPMENT FOR MARINE OPERATIONS SUPPORT**

### **7.1 Arrangements, equipment and systems**

**7.1.1** Object arrangements and equipment used in marine operations include towing, anchor, mooring, bumper and lifting arrangements, positioning system, ballast system, arrangements for on-site 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 the object in a design position. The listed arrangements, and equipment shall ensure complete monitoring of the object throughout marine operations.

Systems, arrangements and associated equipment shall be designed, fabricated, installed and tested in accordance with the relevant standards and provisions of the MODU/FOP Rules and Rules for the Classification and Construction of Sea-Going Ships. The above requirement does not apply to process systems and equipment installed and used only during performance of the operation, and which operating conditions differ from those observed during the object operation. Selection of systems and equipment shall be based on a thorough consideration of their conformity to functional and operational requirements for the marine operation. Emphasis shall be placed on operation reliability and resistance in contingencies.

The issues of ensuring the object course-keeping qualities and the relevant equipment are subject to special consideration by the Register.

**7.1.2** Towing, anchor, mooring and bumper arrangements shall be designed for all relevant loads specified in 2.3, Part II "Hull" of the MODU/FOP Rules or in relevant Chapters of Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships. When designing the towing, anchor, mooring and bumper arrangements the "weak link" principle shall be applied which prevents the damage of the main components of the structure (arrangement) under occasional overloads exceeding the design ones. The structure shall withstand local loads without the loss of overall strength and stability.

**7.1.3** Depending on the complexity and duration of a marine operation, particularly close control over the operation conditions and functioning of various systems both in normal and critical situations is needed to ensure its safe execution. It is generally recommended to consider the following electrical and mechanical systems:

- propulsion plant;

- back-up propulsion plant for power supply in extreme situations;

machinery monitoring systems;  
valve (slide valve) monitoring systems;  
ballast arrangements;  
instrumentation systems;  
fuel system;  
power lines;  
compressor systems;  
fire extinguishing systems;  
navigation systems;  
communication systems.

**7.1.4** All systems, devices and equipment shall be checked and tested prior to the start of operations in accordance with the acceptance list.

**7.1.5** The instrumentation systems and equipment shall generally ensure monitoring of:

loads and deformations of structures and separate components and arrangements;  
environmental conditions;  
ballasting and stability conditions;  
heel, trim and draft of floating objects;  
object position (navigational parameters);  
object under keel clearance;  
object penetration into the seabed.

**7.1.6** The most important systems and equipment including computer networks, etc. shall be duplicated. The reliability of power supply to arrangements and equipment shall be ensured by availability of standby and emergency sources of power which will be activated when the main source of power fails. All systems shall be tested in accordance with the Rules for Technical Supervision During Construction of Ships and Manufacture of Materials and Products for Ships. In the Marine Operation Performance Guidelines, the time necessary for change-over or substitution of the system shall be assessed. The requirements for design and manufacture of primary and back-up systems shall be the same. Back-up systems may be used as an integral part of primary system. For systems consisting of multiple independent units, the back-up may be provided by having a sufficient number of available spare units. Automatic control systems shall be provided with a possibility for manual overriding.

**7.1.7** Non-traditional arrangements and equipment specially installed on the object (joining elements, etc.) shall be properly designed and calculated for loads applied to the object in the course of marine operation.

For review and approval of such arrangements, the following documentation shall be submitted to the Register:

- equipment description;
- general arrangement plan;
- strength calculations;
- material specifications;
- specifications (procedures, processes) for manufacture and installation.

**7.1.8** In some cases, in the course of marine operations, the temporary reinforcement or disassembly of separate parts of the object structure, arrangements and equipment may be needed, which shall be properly reflected in the design of marine operation performance.

**7.1.9** Besides the requirements of this Section, the arrangements, equipment and systems for marine operations support are covered by the requirements of 1.3, Part III "Special Requirements".

## **7.2 Structures**

**7.2.1** All loads on the object structure, arrangements and equipment and the object displacements shall not exceed the allowable levels set in the design of operation performance. The loads in the course of marine operations shall be determined in accordance with the requirements of 2.3, Part II "Hull" of the MODU/FOP Rules and relevant Chapters of Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships.

**7.2.2** Structural elements and components used in marine operations shall be as far as possible flexible and pliable within the prescribed limits. It is not recommended to use an increased air pressure in floating components or underwater air caissons to improve safety in the event of structural damages to the object. This may, however, be permitted in special cases upon thorough consideration of some systems like a drain system, etc. with due regard to the damage consequences, operation duration, etc.

**7.2.3** When developing structure components for marine operations, transmission of tensile stresses through the thickness of rolled steel elements (plates, beams, etc.) shall, as far as possible, be avoided. Transmission of concentrated loads to plate structures shall only be arranged through the intermediate stiffening elements (reinforcements).

**7.2.4** Appendages of the structure located above the waterline shall be designed or protected so as to prevent trapping of water when submerged into water during the object motions, etc.

**7.2.5** Structural elements and their connections are recommended to group according to the following indications:

- type of stresses;
- presence of cyclic loading;

presence of stress concentrations;  
presence of contraction;  
loading rate;  
consequences of failures.

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 damage may result in the hazard to human life, etc;

secondary – structural elements of less importance whose damage does not threaten human life or does not result in significant economic consequences.

The listed categories define requirements for materials and extent of inspection and examination.

**7.2.6** The material quality shall meet the design operational conditions, ensure necessary properties (strength, ductility, toughness, weldability, corrosion resistance), and meet the requirements of current standards specified in 1.4 to 1.6, Part II "Hull" of the MODU/FOP Rules.

**7.2.7** Besides the requirements of this Section, the requirements of 1.3, Part III "Special Requirements" cover the structures supporting marine operations.

## **PART III. SPECIAL REQUIREMENTS**

### **1 REQUIREMENTS FOR BUOYANCY AND STABILITY OF OBJECT, STRUCTURE AND THEIR COMPONENTS DURING MARINE OPERATIONS**

#### **1.1 General requirements for buoyancy and stability**

##### **1.1.1 General.**

**1.1.1.1** The requirements of these Rules specified for the buoyancy, stability and damage stability of any floating components of the structure and the whole object at large shall be fulfilled at all stages of marine operation.

**1.1.1.2** When stability is calculated, it is not recommended to take into account the object structure parts located above the deck, which may occasionally (during significant motions) submerge into water. The effect of such structures on object stability may be admitted in specially specified cases if properly justified. Where additional solid ballast or loads are used to improve stability, reliable seafastening of the solid ballast or loads shall be ensured.

**1.1.1.3** Drainage openings to avoid unacceptable accumulation of water on the object shall be provided in its structure. Where such openings are impracticable, the object stability shall be estimated with due regard to the potential additional volume of water.

**1.1.1.4** In the calculations of stability and reserve buoyancy, due allowance shall be included to account for possible changes in mass, displacement of the object center of mass, density of ballast and sea water. Correction for free surface effects in ballast tanks and other compartments containing liquids shall be included.

**1.1.1.5** When estimating stability, wind and wave effects shall be assumed in accordance with 2.5, Part IV "Stability" of the MODU/FOP Rules or 2.1, Part IV "Stability" of the Rules for the Classification and Construction of Sea-Going Ships.

**1.1.1.6** Inclining tests of floating modules shall be normally performed during construction of the object and prior to marine operations.

**1.1.1.7** The inclining test procedure shall take into account the requirements given in 1.5, Part IV "Stability" of the MODU/FOP Rules. The Register may waive the inclining test provided that the requirements of 1.5.7, Part IV "Stability" of the Rules for the Classification and Construction of Sea-Going Ships are fulfilled.



### **1.1.2 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 substructure when afloat or during local towing shall not be less than 2 m or be equal to a significant wave height (with 13 per cent probability of exceeding level) plus 0,5 m, whichever is greater. Upon agreement with the Register, the application of the requirements specified in 1.2.2.2 is permitted.

For a damaged substructure, when water enters one of the tanks or compartments, the substructure shall remain afloat. In this case, the requirements for the damage waterline specified in 2.5.1, Part V "Subdivision" shall be complied with.

### **1.1.3 Initial metacentric height.**

For an intact structure during the long period of being afloat (construction, unrestricted towing), the initial metacentric height (corrected for free surface effects and effects of air cushions in tanks) shall be at least 1,0 m.

For a damaged structure (with a compartment or tank flooded) the initial metacentric height shall be positive.

Where positioning systems : anchor system, tow lines, mooring lines (from ships and buoys), slings are available, the initial metacentric height shall be calculated with regard to the effect of the above link systems.

### **1.1.4 Stability curves.**

For structures, while being afloat, within the whole range of drafts, i.e. from the initial draft (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 shall be plotted.

The arms of the righting moment curve shall be positive within the range from zero till the angle corresponding to the second intersection of the above curve with the heeling moment curve or 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 considered to be open (as defined in 1.2.1, Part IV "Stability" of the MODU/FOP Rules).

## **1.2 Additional requirements for buoyancy and stability**

### **1.2.1 Self-floating structure.**

#### **1.2.1.1 For intact structure:**

**.1** the cross-curves of stability shall remain positive to the next inclination angle beyond equilibrium:

$$\vartheta \geq (\vartheta_{\max} + 15 + 15/h), \max 40^\circ \quad (1.2.1.1.1)$$

where  $\vartheta_{\max}$  = maximum dynamic inclination due to wind and waves, deg;

$h$  = initial metacentric height, m.

For marine operation of a short duration covered by a reliable weather forecasts (short-term towing, installation on site) an relaxation of the requirement (1.2.1.1.1) may be accepted when the inclination angle may be  $\vartheta \geq 20^\circ$ .

**.2** relationship between the areas formed at the intersection of the righting moment curve with the wind heeling moment curve:

$$(A + B) \geq 1,4 (B + C) \quad (1.2.1.1.2)$$

where areas A, B and C are formed as specified in Part IV "Stability" of the MODU/FOP Rules.

#### **1.2.1.2 For damaged structure:**

**.1** the following relationship shall be fulfilled:

$$(A + B) \geq (B + C); \quad (1.2.1.2.1)$$

**.2** a structure with one tank or tower flooded shall remain afloat and the requirements for damage waterline specified in 2.5.1, Part V "Subdivision" of the MODU/FOP Rules shall be complied with.

### **1.2.2 Transportation and towing.**

#### **1.2.2.1 Barge transporting.**

Relationships (1.2.1.1.1) and (1.2.1.1.2) shall be fulfilled for an intact barge.

During loading the object on a barge, the latter shall have a metacentric height value of at least 1,0 m.

The transverse metacentric height of the barge during transportation shall not be less than 0,3 m with regard to free surface effect.

The range of the righting lever curve shall generally exceed  $40^\circ$ .

The range of the righting lever curve less than  $30^\circ$  is not permitted. Where the range of stability is more than  $30^\circ$  but less than  $40^\circ$ , it shall be shown that the maximum design angle of roll is less than the angle corresponding to the maximum righting arm.

Barge stability calculations shall take into account changes in the design CoG position  $\pm 1$  m in vertical direction and shall also consider the reserve of stability adopted by the shipowner.

When damaged, the barge shall remain afloat with one compartment flooded and the requirements for damage waterline specified in 2.5.1, Part V "Subdivision" of the MODU/FOP Rules shall be complied with.

When evaluating transport barge stability, the righting moment due to the cargo (structure blocks) entering into water shall not be considered. On the contrary, it shall be allowed for the possibility of barge compartment or cargo flooding. For a damaged barge, the relationship (1.2.1.2.1) shall be fulfilled.

#### **1.2.2.2 Towing afloat.**

All the requirements specified in 1.2.1 apply to a structure or module floating either on its own or with the use of temporary buoyancy towers.

A damaged structure, where water enters into one of its compartments or tanks or towers, shall remain afloat, and the requirements for damage waterline specified in 2.5.1, Part V "Subdivision" of the MODU/FOP Rules shall be complied with.

The towed object shall have a corrected initial metacentric height not less than 0,3 m and freeboard not less than 1 m at all stages of towing.

The heeling and righting moments shall be calculated with due regard to the wind, wave, current, icing effects and tug efforts.

#### **1.2.2.3 Launching.**

For launching methods with a considerable dynamic component (longitudinal launching from a barge, launching from inclined slipway) the minimum design freeboard of a structure after launching shall meet the requirements of 1.1.2. In addition, the buoyancy reserve shall ensure a launching trajectory the lowest point of which shall be not less than 5 m above seabed including allowance made for a possibility to damage one compartment during launching. When launching by means of crane assistance, by emersion in the dock, by submersion of a flo-flo ship, the freeboard may be reduced in accordance with the requirements of 1.2.2.2. Following launching, the initial metacentric height shall be positive at the moment of the greatest deepening and thereafter, in equilibrium position, the stability shall meet the requirements of 1.2.1.1.2 and 1.2.1.2.1. In this case, the initial metacentric height for short-term marine operations of a duration less than one day (launching, short-term towing) shall be at least 0,3 m.

When evaluating buoyancy and stability in launching, the emergency flooding of any one compartment or tank or tower shall be taken into account. After damage, the requirements for damage waterline specified in 2.5.1, Part V "Subdivision" of the MOFU/FOP Rules shall be complied with and the structure shall have a positive metacentric height.

### **1.2.3 Buoyancy and stability during vertical mating by float-on method, installation on site and upending.**

**1.2.3.1** In the process of emersion during vertical mating by float-on method and of submersion during installation on site, the metacentric height calculated with due regard to the effect of the buoyancy towers (pontoons) and anchor and mooring lines (and slings if a floating crane is used for supporting) shall be positive within the entire range of drafts and shall also meet the requirements for stability according to 1.2.1, including the case of one compartment, tank or tower flooded.

Installation of a gravity or piled structure on the seabed calls for ensuring stability during submersion. Stability therewith shall be ensured at the expense of the initial metacentric height being at the end of the submersion not less than 1 m (1 to 2 m above the seabed).

**1.2.3.2** During upending, the reserve of buoyancy of the object shall be not less than 10 per cent of the full volume at any stage.

The longitudinal and transverse metacentric heights of the intact and damaged structure shall be at least 1 m.

#### **1.2.3.3 Dynamic parameters evaluation.**

In order to obtain hydrodynamic initial data and to confirm the results of stability calculations, the execution of model tests is recommended for all specified dynamic cases including launching, mating by float-on method, object setting on the seabed.

### **1.3 Requirements for arrangements, equipment, systems and structures affecting buoyancy and stability**

**1.3.1** Special attention shall be paid to ensuring object structure watertightness during marine operations. The number of openings in watertight bulkheads and decks shall be kept to a minimum. Where piping, ventilation ducts and electrical cable pass through decks, outer walls and bulkheads, appropriate arrangements shall ensure their watertightness.

The requirements of the International Convention on Load Lines, 1966 shall be followed with respect to air pipes, overboard and inlet pipes, watertight doors, hatch covers and other openings. Temporary closing devices of the object, such as hatches, blind flanges, plugs and other accessible openings that may be exposed to slamming, flooding, etc. shall be designed for appropriate loads. Where necessary, special protection of such devices shall be provided. Consideration shall be given to possible displacements of the closing devices and supporting structures.

**1.3.2** For a damaged object, the strength of watertight bulkheads and tower walls under a hydrostatic pressure corresponding to the submersion of the structure at trim after an accident shall be ensured. When the transport craft is damaged, the strength of the watertight bulkheads and sufficient strength margin of cargo seafastening (structure or parts thereof) shall be ensured.

**1.3.3** All openings between the object compartments, which may contribute to progressive flooding of the object during operation execution, shall be closed. Regular inspections of compartments tightness, checks of water level in compartments and tanks, checks of the object draft, heel, trim, etc. in search of possible leakage shall be carried out during the operation.

**1.3.4** Requirements for water ballast system to ensure submersion/emersion stability shall include the following items (but not limited thereto):

ballasting system capacity shall ensure the specified time of a marine operation;

in order to prevent the loss of stability due to simultaneous opening of outboard flooding valves (sea valves) of several tanks or towers, the use of those valves is undesirable;

system description shall include instructions on the calculation of a stability curve with due regard to the change of the waterline, centres of gravity and buoyancy, and for corrections for free surface effects in tanks while handling the ballast in its various states.

## **2 FLOATING CRAFT AND TECHNICAL FACILITIES, CREWS AND PERSONNEL INVOLVED IN A MARINE OPERATION**

**2.1** All the floating craft and technical facilities involved in a marine operation, their equipment, machinery, machines and arrangements shall meet the requirements of international conventions, authorized state supervision bodies and classification societies for the conformity to which they are designed.

**2.2** All the floating craft and technical facilities involved in a marine operation, their equipment, machinery, machines and arrangements shall have valid certificates to be effective until the predicted time of completion of the operation and taking into account potential delays.

**2.3** Characteristics of all floating craft and technical facilities involved in a marine operation shall be consistent with those specified in the marine operation design or be superior to those characteristics that enable to perform the marine operation in accordance with the requirements of these Rules.

**2.4** Equipment that is inconsistent with the characteristics specified in the marine operation design or does not comply with the requirements of these Rules shall be interlocked unless its presence affects the normal operation of any other equipment and threatens the safety of the personnel. Otherwise, this equipment shall be dismantled.

**2.5** All crew members of the floating craft intended for operation at sea shall possess adequate qualifications, fully meet the requirements and have all the necessary valid diplomas, certificates and other documents in accordance with the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW Convention 78), as amended. The crew members of craft flying the RF flag shall also have documents in accordance with the Merchant Shipping Code of the Russian Federation and valid orders of the Ministry of Transport of the Russian Federation. Experience in execution of marine operations is recommended.

**2.6** All the crew members of craft intended to operate on the Russian Federation's inland waterways shall possess adequate qualifications, fully meet the requirements and have necessary valid diplomas, certificates and other documents in accordance with the Regulations for Certification of Crew Members of Inland Navigation Vessels, 2005, and orders of the Ministry of Transport of the Russian Federation. Experience in execution of marine operations is recommended.

**2.7** Personnel involved in marine operations shall possess adequate qualifications and experience, have all necessary valid documents confirming their qualification and approval for the works performed during marine operation.

**2.8** All the crew members and personnel involved in a marine operation shall be briefed about the performance of marine operations including emergency actions. For operations with complex communication systems and for the most important systems, provision shall be made for preliminary instructing and training of the personnel under conditions similar to those which are expected during the actual operation. Key personnel participating in the operation shall be familiarized in detail with the procedure of the operation to the extent they are concerned. Other personnel participating in the operation shall be briefed, generally about the operation and specially about safety, damage control, and assigned tasks/responsibilities.

**2.9** For all crew members, in accordance with the normative documents, lessons, training and drills shall be arranged to maintain and enhance the qualifications.

## **3 OBJECT TRANSFER OPERATIONS**

### **3.1 General**

**3.1.1** Among the transfer operations are load in/out operations and other operations (mating, launching, installation) performed by the object lifting or skidding/rolling.

**3.1.2** Prior to operation, a check for readiness shall be carried out, which consists in the following:

equipment and technical facilities are suited to their designed purpose and tested;

Marine Operation Performance Guidelines is approved;

weather forecast for the duration of the operation allowing for the contingencies fits the established restrictions;

results of the object weighing or weight control are satisfactory and accepted by all the participants.

**3.1.3** For operations consisting of several, previously defined phases, the decision on commencement of the operation based on similar principles shall be taken prior to the commencement of each phase.

**3.1.4** To control preparation for the operation it is recommended to use check lists.

**3.1.5** The operation schedule shall take into account the time of high/low tide beginning, as well as time spent for ballasting and object seafastening (releasing/cutting seafastening).

**3.1.6** If loadout supports were previously installed on a craft, their reliability shall be previously checked prior to commencement of loading operation in order to verify that the object can be safely loaded out with the agreed allowances being agreed.

If the loadout supports belong to the object, their consistency with the frames and bulkheads of the craft shall be evaluated by measurements prior to loading.

**3.1.7** The operations shall be mainly performed in the daytime. For operations carried out in darkness sufficient lighting shall be arranged.

### **3.2 Structural analysis**

**3.2.1** Object structure and rigging shall be so designed as to ensure all phases of the operation.

If tilt (turnover) of the object is planned, at least three critical intermediate positions between the horizontal and vertical shall be investigated.

For skidding/rolling operations, strength calculations of the object and support structure during object transfer from the quay onto craft/stability block shall be made.

**3.2.2** In analyzing operations with a partially submerged object, consideration shall be given to the effect of its parts resistance in water.

**3.2.3** Every time when the results of weighing (if provided) show that the actual weight exceeds the maximum expected weight and/or an excessive CoG shift, the calculations shall be revised and, if required, the structure shall be strengthened accordingly.

**3.2.4** To confirm reliability and safety of the operation with an object of inadequately rigid structure (e.g. topside module), it is recommended to develop a three-dimensional elastic model of the object including its cargo handling rigging allowing for appropriate restrictions and assumptions. The model shall include all primary and secondary elements essential for modeling.

Loads incorporated into the model shall be determined with regard to 3.3.

**3.2.5** Safety factors used in strength calculations of the object shall not exceed the values given in Table 2.4.2.5, Part II "Hull" of the MODU/FOP Rules for transportation mode. Recommendations for design of lifting equipment are given in Appendix 1.

### 3.3 Load analysis during object lifting

**3.3.1** For lifting operations strength calculations of the lifting equipment and object shall be made in accordance with the recommendations of this Chapter.

**3.3.2** Calculation stages of the object lifting by means of one/two cranes assistance are shown in Figs. 3.1 and 3.2, respectively.

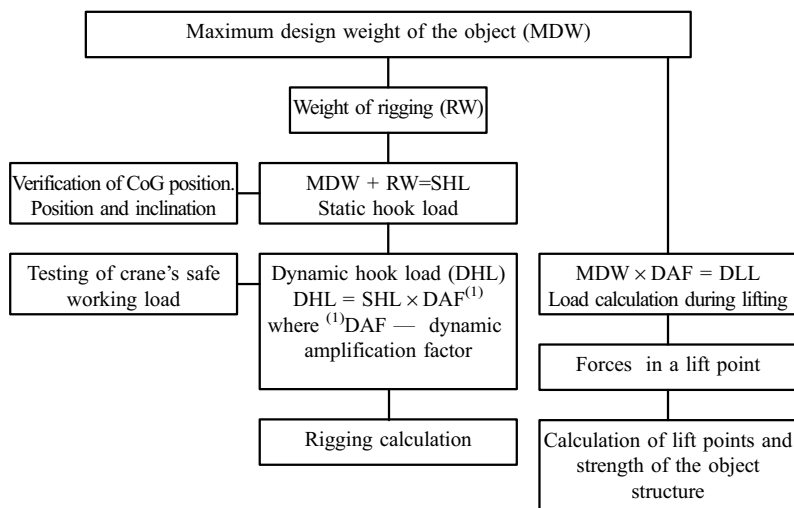


Fig. 3.1 Calculation stages of the object lifting by one crane



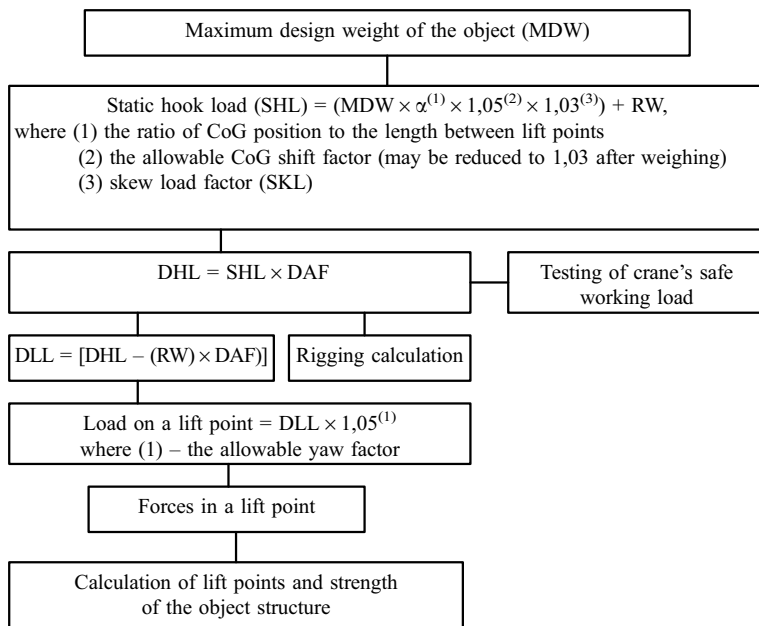


Fig. 3.2 Calculation stages of the object lifting by two cranes

**3.3.3** Maximum design weight of the object (MDW) shall take account of the mass margin.

When calculating the MDW value at the design stage, the weight of the object shall be determined separately for the following elements:

weight of structural steel with allowances assumed for thicknesses, painting, welds, inaccuracy of linear dimensions and other additions increasing the design weight. For this group, it is recommended to assume the mass margin to be equal to 10 per cent of the total mass of the elements included into this group;

weight of the equipment and ancillary elements that takes account of the allowable inaccuracies in evaluating weight of the essential and additional equipment and steel structures (foundations and working platforms). For this group, the design weight shall be increased by 20 per cent.

Upon completion of construction, the object shall be weighed using agreed weighing methods and the value obtained, considering inaccuracies in weighing, shall be increased by 3 per cent. The fact that such value of error may be admissible shall be confirmed in the design documentation. If the object

If the weight of constructed object plus mass margin exceed the design weight of the object the calculations associated with the lifting design shall be checked.

The value  $e$  in Fig. 3.3.4 shall not exceed 0,02 of the vertical distance from the crane hook to the CoG of the lifted object.

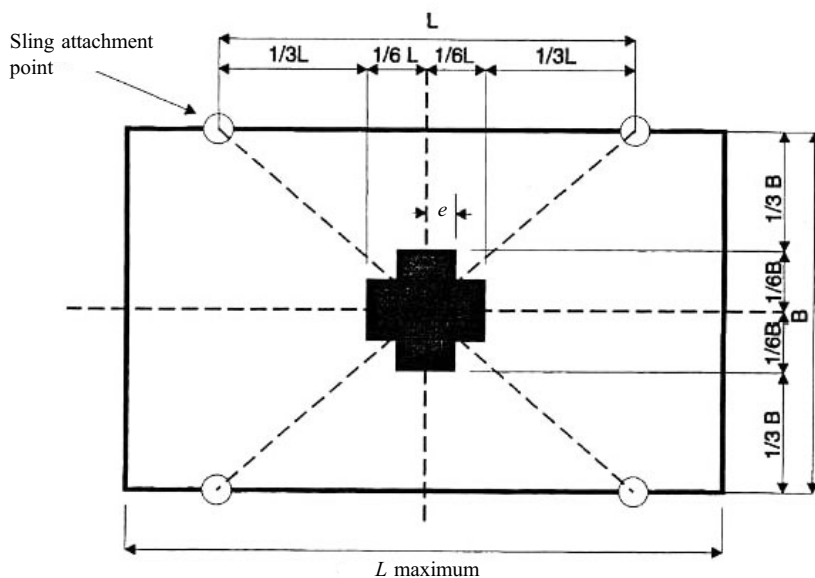


Fig. 3.3.4  
Allowable CoG position

If the CoG of the lifted object is located outside the shaded zone, as shown in Fig. 3.3.4, the possibility of lifting shall be confirmed by appropriate calculations.

The length of the lift sling shall be selected proceeding from the minimization of inclinations of the object axes during lifting. Unless expressly provided otherwise, the object tilt shall not exceed  $2^\circ$ .

In case when the object was weighed, its static tilt shall be calculated with due account of measurement of the CoG position and sling length. In this case, the shift between the position of the hook center and the CoG of the lifted object shall be not exceed 600 mm.

**3.3.5** Particular attention in designing the lifting operation shall be given to selection/confirmation of the CoG position with respect to the point of the object suspension from the crane hook.

Along with that, consideration shall be given to the fact that the main influence on this position is exerted by:

- the number and length of slings;
- the crane hook load value;
- the allowable tilt the lifted object.

### **3.4 Static hook load**

**3.4.1** The static hook load (SHL) shall be determined by the Formula (3.4.1-1) for a lift by one crane, and by the Formula (3.4.1-2) for a lift by two cranes:

$$\text{SHL} = \text{MDW} + \text{RW}; \quad (3.4.1-1)$$

$$\text{SHL} = \text{MDW} + \alpha \times 1,05 \times 1,03 + \text{RW}. \quad (3.4.1-2)$$

SHL be tested with respect to the crane safe working load at the maximum design arm of crane. In case of lifting through water and lifting by two cranes, the buoyancy and hydrodynamic loads can change the load distribution between two hooks. These effects shall be taken into consideration when determining individual hook loads.

**3.4.2** The dynamic hook load (DHL) can be determined by multiplying the SHL by the dynamic amplification factor (DAF) (Table 3.4.2):

$$\text{DHL} = \text{SHL} \times \text{DAF}.$$

DAF induces a correction for dynamic loads arising from crane ship and/or cargo barge motions during lifting operations.

DHL shall also be tested for correspondence to the crane safe working load at the maximum design arm of crane.

Where lifting is performed in air, the dynamic load is generally regarded as the greatest load at the time when the object takes off the system of cross members.

Table 3.4.2

**Relationship between DAF and lifting conditions**

Object weight	< 100 t	100—1000 t	1000—2500 t	> 2500 t
Inshore lifts	1,0	1,0	1,0	1,0
Column-stabilized floating crane				
Offshore lifts in air	1,30	1,20	1,15	1,10
Offshore lifts from deck	1,15	1,10	1,05	1,05
Onshore lifts in air	1,15	1,10	1,05	1,05
Floating crane/crane ship				
Offshore lifts in air	1,50	1,40	1,30	1,20
Onshore lifts in air	1,30	1,20	1,15	1,10

This load and the relevant DAF shall be determined by design analysis wherein consideration is given to the maximum transfer of the lifted object in relation to the barge from which it has been offloaded. The calculations shall take account of the elasticity of crane ropes, booms and cargo-gripping devices.

Based on the results of such analysis, weather restrictions (primarily, wave heights and periods) shall be established. If the DAF design value is found to be critical for execution of the operation, then during lifting it will be necessary to monitor weather conditions, and the operation performance period shall be selected on the basis of the analysis of weather condition statistics in the lifting operation area.

**3.4.3** Attachment points for slings shall be provided on the object.

Loads on sling attachment points (lift points) shall be determined by calculation of design lifting loads (DLL) and by consideration of the geometry of load-gripping device and of the CoG position of the object for a single crane using the Formula (3.4.3-1) and for two cranes using the Formula (3.4.3-2):

$$DLL = MDW \times DAF; \quad (3.4.3-1)$$

$$DLL = DHL - (RW \times DAF). \quad (3.4.3-2)$$

To confirm safety of lifting, the analysis of load distribution between the diagonally opposite pair of lift points with due account for the object rigidity and sling elasticity shall be made. Where the information on the errors of the object manufacturing and slinging is lacking, it is recommended to take into account the following assumptions in such analysis:

each lift point is located 12 mm from its design position (account shall be taken of the integral effect due to position errors of all lift points in relation to their design position);

two shackles, each one being 6 mm shorter than its standard size, are secured to the diagonally opposite attachment points, whereas two shackles that are 6 mm longer than the standard size are secured along another diagonal;

slings that 0,25 per cent shorter than the specified nominal length are secured to two diagonally opposite lift points while the slings that 0,25 per cent longer than their nominal length are secured to two remaining lift points.

The load on the lift point shall be increased by 5 per cent to account for rotation/swinging of the lifted object.

**3.4.4** When the object is lowered from the surface down to its final position on seabed, the object buoyancy and center of buoyancy (CoB) shall be established on the basis of accurate hydrostatic analysis.

When evaluating impact loads on the object being submerged, due to the impacts during setting down or lowering onto the seabed the object submersion rate shall not be taken less than 1 m/s.

Environmental loads acting on the object shall be evaluated and used to obtain the loads pulling the object away from the crane and the lateral forces applied perpendicular to the crane arm axis.

At the preliminary design stage, the DAF value may be taken equal to 1,4 for lifting of small structures from the water. For large-sized objects, the DAF may be taken equal to 1,2.

**3.4.5** Asymmetrical distribution of loads in the slings shall be taken into account in every object slinging diagram. Such asymmetry may be evaluated through the skew load factor (SKL) considering relative rigidity and weigh of the lifted object and slings, mismatch and deviations of the sling lengths within the tolerances and other inaccuracies of force distribution in slings.

SKL shall be taken into account in the design of the whole structure, lift points, slings, connecting shackles and spreader bars or frames.

For the statically indeterminate four lift points with one of the following slinging arrangements:

four slings directly from four lift points to hook;

four slings to hook with intermediate spreader frame ;

four slings to hook with two intermediate spreader bars

SKL shall be taken from Table 3.4.5.

Table 3.4.5

**Load distribution and SKL**

Statically indeterminate four lift points	Rigid structure	Non-rigid structure
SKL	1,50	1,33
Asymmetrical load distribution in any set of diagonally opposite slings	75/25 %	67/33 %

For statically determinate four lift points with one of the following slinging arrangements SKL equal to 1,10, i.e. asymmetrical load distribution in any set of diagonally opposite slings 55/45 per cent:

- four slings to hook with two intermediate unsecured spreaders;

- two slings to hook with one intermediate spreader.

For statistically determinate three lift points the SKL is equal to 1.

### **3.5 Cranes and crane ships**

**3.5.1** The dynamic hook load shall be consistent with the crane capacity chart. The crane shall be equipped with a load measuring device.

**3.5.2** If the lifted object is gripped at several points, consideration shall be given to the effect of rotation about horizontal axis and tilts which may result from displacement of the hooks from their ideal relative positions.

In the absence of a significant load due to wind or tension of auxiliary winch ropes a minimum yaw effect factor (YEF) equal to 1,05 shall be used.

If cranes are installed on the same ship the above factor shall be calculated for a tilt equal to 3°, and if cranes are installed on separate ships it shall be calculated for a tilt equal to 5°.

These factors shall be taken into account for in the design of lift points, slings, connecting shackles and spreader or frames.

**3.5.3** If the design hook load is less than 80 per cent of the crane safe working load, and the ship performs lifting at an operating draft, no submission of stability calculation is required. However, if the load is close to allowable maximum for the ship or the ship's draft is beyond the normal operating range, the stability calculation shall be submitted for review.

Where lift is carried out by two cranes, documentation shall be submitted to prove that the crane ship is capable to ensure safe change in the hook load which arises at tilt angles and yaw factors under environmental impact, especially considering allowable transverse angles for crane arms.

**3.5.4** The crane shall have sufficient capacity and the crane barge – sufficient stability at all stages of the operation.

**3.5.5** Arrangement of slings on the hook shall be symmetrical to avoid tilt of cargo and angle between the ropes and sheaves. Unsymmetrical arrangement shall be considered with due regard to the hook strength and its displacement, and shall be approved by the crane manufacturer.

**3.5.6** During all stages of lifting the following minimum clearances shall be ensured:

- under the object — 3 m;

- between the object and the arm of crane — 3 m;

- between the spreader bar and the arm of crane — 3 m;

- between the crane ship and the object — 3 m (crane ship is lying at anchor);

between the crane ship and the object — 10 m (crane ship uses dynamic positioning system).

### **3.6 Load in/out operations**

**3.6.1** Prior to operation the seabed area shall be examined to verify that the under-keel clearance both during load out and thereafter is sufficient, and that there are no underwater obstructions for operation.

Number of the sounding points shall be sufficient to exclude undetected obstructions. When substantiating sufficiency of depth, consideration shall be given to tidal conditions, waves, swell, barometric pressure and the lowest possible low water.

In this case, mud thickness shall be measured. The results of measurements shall be plotted on a chart with the date of measurements marked.

The minimum under-keel clearance (vertical clearance) throughout the loading operation shall be not less than 0,5 m taking account of the craft heel and trim.

**3.6.2** The transport craft shall be kept at a design location during performance of a load out operation until seafastening is completed.

**3.6.3** Selection of the restricting conditions with respect to wind velocity and wave height shall take account of the quay position, operation duration and operation peculiarities, range of sea level variations due to tidal conditions. If the quay is protected against wave impacts, the effect of the latter may be considered as insignificant. If the quay is exposed to the effect of the long-period swell waves, the design value of the wave period shall be approved by the Register.

**3.6.4** The following load out monitoring facilities shall be installed:

barge draft, heel and trim;

water level in barge ballast tanks;

tide level;

displacement of the object on barge.

When deflections of the barge from the quay and alignment of the barge with the quay are critical, the monitoring thereof shall be provided using geodetic equipment.

**3.6.5** A possibility shall be provided to verify valid certificates for constituent parts of rigging, especially for slings, thimbles and shackles, as well as the documentation on the results of weld inspection at lift points. If the object was lifted more than once, prior to the second and next lifts a detailed visual examination of the welds at lift points shall be carried out by a competent expert in the presence of the surveyor to the Register.

**3.6.6** The final position of the object on loadout supports shall be clearly marked.

**3.6.7** When approaching the specified position, the deflections in the object position shall not exceed:

vertical:  $\pm 0,75$  m;

horizontal:  $\pm 1,50$  m in any direction;

inclination:  $2^\circ$ ;

turning around vertical axis:  $3^\circ$ .

**3.6.8** Upon completion of load out operation, regular monitoring of the reliability of the barge mooring lines, draft, heel and trim shall be provided.

Under unfavourable weather conditions, the continuous barge monitoring shall be provided. An adequate number of spare mooring lines of required dimension and in proper condition shall be provided during the barge berthing.

If a sub-zero temperature is expected, measures shall be taken to avoid freezing of water in tanks and on deck. Similar precaution shall be taken in respect to liquids in machinery installation and systems.

### **3.7 Object offshore lifts**

**3.7.1** During the operation, craft shall be kept in specified position by means of mooring designed to be capable to withstand extreme values of wind, current and waves occurring once in every 10 years provided that one line breaks.

**3.7.2** If buoys or anchors are required for mooring, they shall be installed and tested prior to the operation.

**3.7.3** Restriction of the operational criterion shall be based on the results of crane ship motions evaluations, depending on sea state. To verify the design restrictions it is recommended to carry out model tests or an appropriate computer simulation.

**3.7.4** For subsea structures or submerged part of the object subjected to wave loading, which is considerable for them, the maximum permissible wave conditions shall be established, primarily, as regards lengths and directions of waves including swell. Effect of wave impacts in the splash zone shall be also evaluated.

Consideration shall be given to hydrostatic and hydrodynamic loads on the object being submerged.

### **3.8 Load analysis during skidding/rolling**

**3.8.1** In calculating loads arising during skidding/rolling consideration shall be given to the following:

weight and rigidity of the object and its supporting structures;

friction forces;

resistance of non-propelled trailers;

winch pull;

race/rail track tolerances;



craft/stability block heel and trim;  
soil subsidence (in case of the craft/stability block setting on the seabed during the operation).

**3.8.2** At the stage of developing skidding /rolling operations, the following values of errors in determination of mass-dimensional characteristics shall be taken into account:

unaccounted weight: 10 per cent;

CoG shift: longitudinal  $\pm 1,0$  m, transverse  $\pm 0,5$  m.

**3.8.3** Final load distribution in the object structures, support structures and hydraulic system of the trailers shall be confirmed after weighing of the object before the operation.

**3.8.4** To avoid deformations of the object when loaded out while being supported at more than three points, provision shall be made for a load equalizing system.

**3.8.5** When the object is transferred onto a craft by skidding or rolling method while resting on the seabed, the craft strength, primarily, the strength of longitudinal bulkheads shall be checked.

**3.8.6** When calculating loads required to start moving the object, consideration shall be given to friction forces, inertia forces, as well as the horizontal component of gravity force during skidding or rolling on sloping surface.

**3.8.7** The friction coefficient values shall be established on the basis of test results or previous experience. Data given in Table 3.8.7 may be also used.

Table 3.8.7

Recommended friction coefficients for level surfaces						
	Static			Dynamic		
	Min.	Typ.	Max.	Min.	Typ.	Max.
<b>Sliding</b>						
Steel/Steel	0,15	0,20	0,35	0,10	0,15	0,25
Steel/Grease/Steel	0,10	0,15	0,30	0,08	0,12	0,20
Steel/Teflon	0,10	0,15	0,25	0,04	0,05	0,10
Stainless steel/Teflon	0,08	0,10	0,20	0,03	0,04	0,07
Teflon/Grease/ Dressed Wood	0,08	0,14	0,25	0,03	0,06	0,08
Teflon/Grease/Wood	0,10	0,18	0,30	0,05	0,10	0,15
Steel/Wood	0,20	0,40	0,60	0,15	0,30	0,40
Steel/Grease/Wood	0,15	0,30	0,40	0,10	0,15	0,20
Rubber tyres (fixed)	0,20	0,35	0,50	—	—	—
<b>Rolling</b>						
Steel wheels/Steel		0,01			0,01	
Rubber tyres/Steel	0,01		0,02	0,01		0,02
Rubber tyres/Gravel	0,02		0,06	0,02		0,04

**3.8.8** When evaluating loads on winches, rigging, jacks and braking system, consideration shall be given to at least unfavourable longitudinal slope of the track being equal to 1:100.

### **3.9 Skidding/rolling operations**

**3.9.1** During loading with the use of trailers, loads acting thereon shall not exceed allowable limits established by the manufacturer, namely:

- loads on the trailer hydraulic suspension;

- loads on the axis;

- shearing and bending stresses of the main longitudinal beam of the trailer.

When substantiating the possibility of using this method of loading operation, consideration shall be given to:

- seabed level and ramp/spoon slope;

- object sagging;

- allowable barge heel and trim;

- trailer hydraulic suspension stroke.

When designing the operation, it is recommended to provide a jam travel margin not less than 100 mm.

The object shall be secured in such a manner as to prevent its movement relative to the trailers.

**3.9.2** Provision shall be made for a braking system capable to stop moving of the object transferred.

A reverse movement system shall be provided to return the object to its starting point in an unforeseen situation unless it is proven that the craft with the object on board can be at the same level with the quay/stability block during the skidding/rolling operation with due account of possible delays and effect of tide variations.

**3.9.3** The design load on the traction system shall not exceed the certified safe working load (SWL) of the system. Two modes: start and steady movement shall be evaluated. When calculating the SWL of rope systems, proper assumption shall be made regarding bending of wire ropes and also friction losses in sheaves.

The traction systems shall enable the object to be transferred from support to support with no changes of rigging, and in case of failure of any component or secondary system the said systems shall continue to operate effectively.

**3.9.4** Capacity of main electrical power source shall be sufficient to supply all the equipment which may be used during the operation to ensure continuous operation of the machinery at maximum capacity.

Provision shall be made for stand-by power supply sufficient for safe completion of the operation.

**3.9.5** When rolling the object with the use of trailers, the design position of the object and the possibility of its adjusting with the use of shims shall be checked during lowering the object to its seat. Lowering shall not be completely finished until the satisfactory adjustment and positioning are carried out and accepted. If there are more than four points for the object support, preliminary alignment shall be carried out by ballasting.

**3.9.6** Prior to load out, all the preparations for seafastening shall be completed. Seafastening shall commence as soon as possible after lowering the object and in such sequence as to make it possible to keep it in horizontal position when stowed for sea in a minimum of time and prevent inadmissible stresses in the object structures.

## **4 TRANSPORTATION/TOWING OF THE OBJECT**

### **4.1 Local and global strength of craft loaded during marine operation**

**4.1.1** The loading operation manual shall contain local and global strength calculations for the craft loaded during marine operation.

**4.1.2** The local and global strength of the craft loaded during a marine operation shall satisfy the requirements of Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships.

**4.1.3** In case where the local and/or global strength does not satisfy the requirements of the above mentioned Part, it will be necessary to provide and calculate arrangements for re-distribution of forces, moments and loads or the craft hull strengthening in order to ensure compliance with the requirements of 4.1.2.

### **4.2 Calculation and means for securing the object on craft**

**4.2.1** Every object or parts thereof shall be individually secured on the craft by attachment to the craft hull.

**4.2.2** Flexible, semi-rigid and rigid industrial products, as well as those manufactured in accordance with the marine operation design (stops, brackets, braces, wedges, etc.) shall be used as the means for securing the object.

**4.2.3** When the object is secured by means of stops, braces, brackets and other fixed elements, they shall be fitted in the plane of the stiffeners being part of the craft hull framing.

**4.2.4** Calculations of loads on the structural elements of the securing system shall be made with due account of the safety factor  $K_s$  being equal to 1,3.

**4.2.5** Where lashings are used for securing the object their points of attachment to the object and craft, as well as their elements shall be of the same strength, or shall exceed the allowable loads (refer to Table 4.2.5).

Table 4.2.5

Strength standards of securing means

Type of securing means	Safe working load (SWL)	Test load (TL)	Breaking load (BL)	Safety factor
Rope, car lashings	$0,33 \times BL$	$1,25 \times SWL$	$3,0 \times SWL$	3
Chain lashings	$0,4 \times BL$	$1,25 \times SWL$	$2,5 \times SWL$	2,5
Bars, turnbuckles, straps, jacks	$0,5 \times BL$	$1,25 \times SWL$	$2,0 \times SWL$	2
Other devices	$0,5 \times BL$	$1,25 \times SWL$	$2,0 \times SWL$	2

**4.2.6** During a marine operation the object is subjected to weight forces, inertia forces in motion, friction forces, reaction forces of loadout supports and securing elements, while the objects on the open deck are subjected to wind pressure and wave loads. The craft with the object on board is subjected to surging oscillation, rolling, pitching, heaving and yawing which produce certain accelerations and inertia forces. The calculations of seafastening of the object and/or parts thereof on board the craft shall take account of particular, significantly important components of the said forces in coordinates related to the craft, with its origin at the intersection point of the base line, midship section and centreline (CL) of the craft. The X-axis is directed forward, the Y-axis to starboard, and the Z-axis upwards.

**4.2.7** Where the object is transported on a craft with length exceeding 80 m, breadth exceeding 12 m, draft exceeding 3 m, length to breadth ratio from 5 to 10, breadth to draft ratio from 2 to 6, transverse metacentric height from 0,3 to 3,5 m, transverse metacentric height to breadth ratio from 0,02 to 0,12, Froude number for design speed from 0 to 0,3, CoG position not higher than 6 m above the upper deck, the dimensionless projections of the total weight and inertia forces acting on the object shall be determined by the formula:

$$\left. \begin{aligned} \bar{X} &= A \cdot (0,18 + 12/L), \\ \bar{Y} &= A \cdot (0,3 + 20/L) \cdot K, \\ \bar{Z} &= 1,0 + A \cdot (0,36 + 25/L), \end{aligned} \right\} \quad (4.2.7)$$

where  $A = 0,25 + 0,45h_{3\%} + 0,25\sin(0,28h_{3\%} - 1,573)$ ;

$\bar{X}$ ,  $\bar{Y}$ ,  $\bar{Z}$  = design dimensionless projections of weight and inertia forces, acting on the object in direction of coordinate axes;

$L$  = ship's length between perpendiculars, in m;

$K$  = coefficient is equal to 1 if bilge keels with the area over 1,5 per cent of the waterline area are provided, and equal to 1,4 where no bilge keels are provided. If the area of bilge keels is less than 1,5 per cent, the value of  $K$  shall be determined by linear interpolation.

**4.2.8** If the length or breadth of the transported object exceeds the overall dimensions of the craft or the craft parameters are inconsistent with those specified in 4.2.7 and 4.2.9, or the craft is multi-hulled, the calculation of motions which takes account of the following shall be submitted to the Register for approval:

actual hull shape, the value of the craft's metacentric height and speed;  
actual arrangement of the object;  
dimensions of bilge keels;  
angle between the craft direction and mean wave direction;  
non-linearity of rolling associated with the relationship between non-wave damping and roll amplitude;

spectral density of the wave ordinates corresponding to set wave height and mean wave period (based on one of the approved spectra: JONSWAP or Pierson-Moskowitz, etc.), shall be submitted to the Register for approval.

The calculations shall be made both for dead swell and for the two- and three-dimensional irregular waves depending on their intensity. The amplitudes of motions and accelerations accounting for wave height with 3 per cent probability shall be taken as the design ones.

For weather-unrestricted operations, the accelerations at motions may be calculated using the procedure specified in 1.3.3, Part II "Hull" and Part III "Arrangements, Equipment and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships.

**4.2.9** Where the object is transported on a craft having the shape of a rectangular pontoon, with length from 30 to 90 m, breadth to draft ratio from 4 to 8, metacentric height to breadth ratio from 0,02 to 0,12, length to breadth ratio from 3 to 6, at wave height with 3 per cent probability, the design dimensionless projections of wave and inertia forces acting on the object or parts thereof shall be determined by the formula:

$$\left. \begin{aligned} \bar{X} &= \frac{h_{3\%}}{5} \cdot (0,27 - 0,001 \cdot L - 0,01 \cdot B/T), \\ \bar{Y} &= \frac{h_{3\%}}{5} \cdot (0,65 - 0,0034 \cdot L) \cdot (0,086 + 0,35 \cdot B/T) \times \\ &\times [1,0 + (0,015 \cdot L - 0,45) \cdot (h/B - 0,02) \cdot (8 - B/T)], \\ \bar{Z} &= \frac{h_{3\%}}{5} \cdot (1,235 - 0,005 \cdot L + 0,005 \cdot B/T), \end{aligned} \right\} \quad (4.2.9)$$

where  $L$  = ship's length between perpendiculars, in m;  
 $B$  = ship's breadth, in m;  
 $T$  = ship's draft, in m;  
 $h$  = metacentric height, in m.

**4.2.10** Supporting surface of the object are subjected to frictional forces the design dimensionless projections of which along the X and Y axes shall be determined by the formula:

$$\bar{X}_f = \bar{Y}_f = f_0 \left[ (2 - \bar{Z}) + \frac{\sum Z_{pret}}{P} \right] \quad (4.2.10-1)$$

where  $f_0$  = coefficient of static friction which standard values are given in Table 4.2.10;

$Z_{pret}$  = vertical component of the pre-tension of the i-th cargo securing lashing;

$P$  = cargo weight, in tf (numerically equal to cargo mass in tonnes).

$Z_{pret}$  value is accounted for only when the tension of lashings is permanent and shall be determined by the formula:

$$Z_{pret} = 0,0833 T_{br} \sin \alpha \quad (4.2.10-2)$$

where  $T_{br}$  = breaking strength of the lashing, in tf;

$\alpha$  = angle of lashing inclination to supporting surface.

The vertical component of the inertia force is directed upwards in the Formula (4.2.10-1), therefore the value of friction force determined from this formula is the minimum possible value (error is included into safety margin for securing elements)

Table 4.2.10

Friction pair	Coefficient of static friction, $f$
Cast iron on steel	0,32
Cast iron on wood	0,72
Steel on steel	0,21
Steel on wood	0,5
Reinforced-concrete on wood	0,55

**4.2.11** The design dimensionless projections of wind pressure forces (acting only on the object or parts thereof located on the open deck) shall be determined by the formula:

$$\left. \begin{aligned} \bar{X}_v &= 0,15 \cdot F'_v / P, \\ \bar{Y}_v &= 0,15 \cdot F''_v / P \end{aligned} \right\} \quad (4.2.11)$$

where  $F'_v$  and  $F''_v$  = a portion of cargo projection above bulwark on the midship section and centreline, in m<sup>2</sup>. The areas  $F'_v$  and  $F''_v$  for non-continuous structures shall be taken with regard to their permeability, and in winter time with regard to icing, assuming that the ice thickness is equal to 0,05 m;

$P$  = cargo weight, in tf (numerically equal to cargo mass in tonnes).

**4.2.12** The wave force in transverse direction shall be considered only for the object or parts thereof located on the open deck at a distance not exceeding 3 m from the side. The value of the design dimensionless projection of transverse wave force shall be determined by the formula:

$$\bar{Y}_w = 0,5 \cdot (h_w - h_b)^2 \cdot \frac{l}{P} \quad (4.2.12)$$

where  $h_w$  = the greatest height of cargo above the waterline, in m (  $h_w > h_{3\%}$ , then  $h_w = h_{3\%}$ , if  $h_w \leq h_{3\%}$ , it is assumed that  $\bar{Y}_w = 0$ );

$h_b$  = height of the bulwark top above the effective waterline, in m;

$l$  = cargo length along the side, in m;

$P$  = cargo weight, in tf (numerically equal to cargo mass in tones).

The point of application of the wave force is situated at a height  $h = 0,667h_b + 0,333h_w$  above the effective waterline.

**4.2.13** The summarized axial projections from the force acting on the cargo shall be determined by adding together the projections of loads along relevant axes determined by the Formulae (4.2.7) or (4.2.9), (4.2.10-1), (4.2.10-2), (4.2.11) and (4.2.12):

$$\left. \begin{aligned} X &= P(\bar{X} + \bar{X}_v - \bar{X}_f) \geq 0, \\ Y &= P(\bar{Y} + \bar{Y}_v + \bar{Y}_w - \bar{Y}_f) \geq 0, \\ Z &= P\bar{Z} + \Sigma Z_{pret} \end{aligned} \right\} \quad (4.2.13)$$

where  $P$  = cargo weight, in tf or kN;

$X$  = component of the design shear force leading to the cargo shift in the direction of the X-axis, in tf or kN;

$Y$  = ditto, in the direction of the Y-axis, in tf or kN;

$Z$  = vertical component of the support response, in tf or kN;

$\bar{X}, \bar{Y}, \bar{Z}$  = dimensionless values determined by the Formulae (4.2.9);

$\bar{X}_v, \bar{Y}_v$  = dimensionless components of wind pressure forces determined by the Formula (4.2.11);

$\bar{X}_f, \bar{Y}_f$  = dimensionless components of friction forces determined by the Formula (4.2.10-1);

$\bar{Y}_w$  = dimensionless component of wave force determined by the Formula (4.2.12);

$\Sigma Z_{pret}$  = sum of the vertical components of lashing pre-tension is determined by the Formula (4.2.10-1) in accordance with the provisions of 4.2.10 taking into account that the breaking strength of the lashing is taken in the same system of units in which the  $Z$  force is determined.

The calculated values of  $X$  and  $Y$  cannot be negative since the frictional forces cannot exceed the shear forces. If, however, the values of  $X$  and  $Y$  calculated by the formulae appear to be negative, it is necessary to assume that  $X=0$  and  $Y=0$ , respectively. In this case, no securing means that stop shifting of the object and/or parts thereof shall be provided.

**4.2.14** The design of sea fastening shall, wherever possible, provide for a minimum number of elements in order to minimize load irregularity between them.

**4.2.15** The sea fastening elements are subdivided into those which prevent shift of the object and/or parts thereof and those which prevent its overturning. Where possible, it is necessary to separate the sea fastening element intended to prevent the object shift, and the elements which prevent its overturning. Statically determinate cargo securing devices shall be provided.

**4.2.16** In order to reduce the size of sea fastening, it is recommended to take measures to increase forces of friction between the object and/or parts thereof and the supporting surface, and the elements preventing its overturning shall be located as far from the estimated overturning axes as practicable.

**4.2.17** All sea fastening elements shall be reliably attached to the craft hull structures, which strength and rigidity shall be substantiated by a calculation. In calculating it shall be taken into account that the estimated longitudinal and transverse overturning axes pass through the elements preventing shifting.

**4.2.18** Moments of forces overturning the cargo about axes ( $M_x$  — about longitudinal axis,  $M_y$  — about transverse axis) shall be determined by the formula:

$$\left. \begin{aligned} M_x &= P[(\bar{Y}l_{\bar{y}} + \bar{Y}_v l_{yv} + \bar{Y}_w l_{yw} - (2 - \bar{Z})l_{yz}], \\ M_y &= P[\bar{X}l_{\bar{x}} + \bar{X}_v l_{xv} - (2 - \bar{Z})l_{xz}], \end{aligned} \right\} \quad (4.2.18)$$

where  $l_{\bar{y}}$  and  $l_{\bar{x}}$  = arms of  $\bar{Y}$  and  $\bar{X}$  forces applied to the cargo centre of gravity about the estimated overturning axes, in m;

$l_{yv}$  and  $l_{xv}$  = arms of  $\bar{Y}_v$  and  $\bar{X}_v$  forces applied to the windage centers, in m;

$l_{yw}$  = arm of  $\bar{Y}_w$  force about estimated longitudinal overturning axis, in m;

$l_{xz}$  and  $l_{yz}$  = arms of  $(2 - \bar{Z})$  force applied to the cargo centre of gravity about the above mentioned axes.

Diagram of forces acting in the transverse plane and possible arrangement of sea fastening elements are shown in Fig. 4.2.18.

For large-sized cargoes, in calculating the overturning moment due to action of the resultant components of inertia forces reduced to the cargo centre of gravity, the main moment of inertia forces resulted from non-uniform distribution of inertia forces over the large-sized cargo elements and depending on the cargo intrinsic moment of inertia of the shall be considered.

**4.2.19** The formulae given in 4.2.18 correspond to properly designed stops which prevent shifting when the reaction force of these stops is applied near supporting surface. Otherwise, consideration shall also be given to the moment of friction forces.

**4.2.20** If the values of moments  $M_x$  and  $M_y$ , obtained by calculations are negative, this indicates that the object is sufficiently stable and any securing to prevent its overturning is not required. Adequate allowance is provided when determining vertical force with consideration for unfavourable phase relationship.



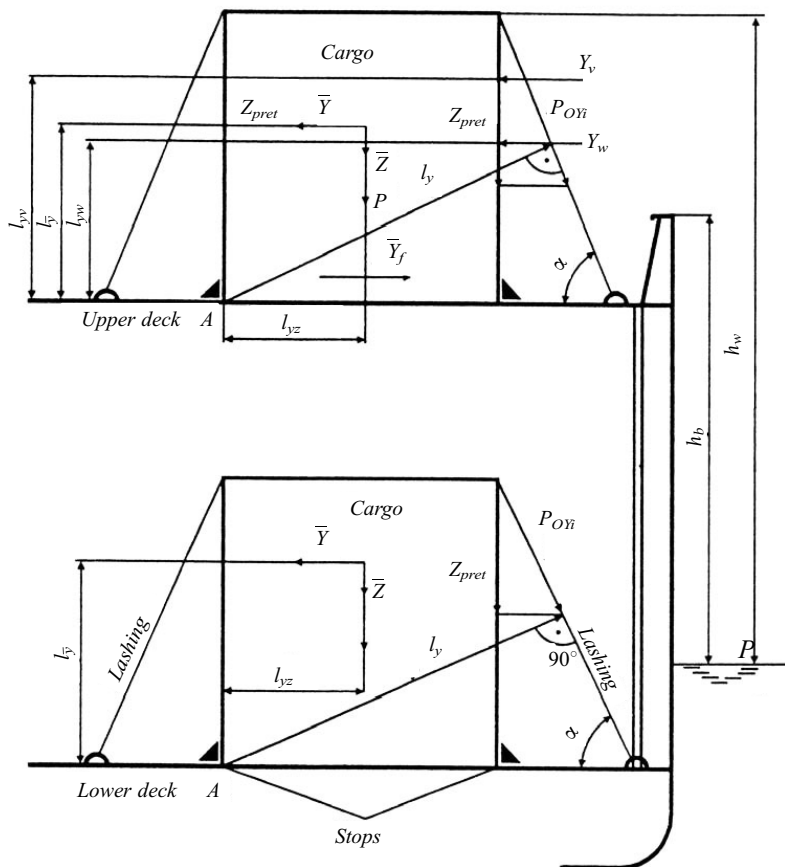


Fig. 4.2.18

**4.2.21** For the securing structure in question, the horizontal forces acting on identical elements preventing transverse and longitudinal shifting shall be determined by the formula:

$$\left. \begin{aligned} P_{1x} &= X/n, \\ P_{1y} &= Y/m, \end{aligned} \right\} \quad (4.2.21-1)$$

where  $X$  and  $Y$  = design forces determined by the Formula (4.2.13), in tf;  
 $n$  and  $m$  = number of stops preventing cargo shifting.

Forces  $P_{ox}$  and  $P_{oy}$  tensioning longitudinal and transvers lashings, respectively, shall be determined by the formula:

$$\left. \begin{aligned} P_{ox} &= \frac{M_y}{n_0 l_x \cos \beta_x} , \\ P_{oy} &= \frac{M_x}{m_0 l_y \cos \beta_y} , \end{aligned} \right\} \quad (4.2.21-2)$$

where  $M_x$  and  $M_y$  = moments determined by the Formulae (4.2.18), in tf;

$n_0$  and  $m_0$  = number of longitudinal and transverse lashings;

$l_x$  and  $l_y$  = arms about longitudinal and transverse axes, in m;

$\beta_x$  and  $\beta_y$  = angles of inclination of lashing projections on supporting surface to axes  $X$  and  $Y$ , respectively.

**4.2.22** In case where the transported object and/or parts thereof are welded to deck, it may be assumed that the same welds perform conditionally separate functions, that is, the Formulae (4.2.9) and (4.2.10-1) may be used, assuming that  $n = n_0$  and  $m = m_0$  are the number of similar welds (parts of intermittent weld) and that  $l_x$  and  $l_y$  are the distance between the transverse (approximately, cargo length) and longitudinal (approximately, cargo width) welds, respectively. Forces applied to welds shall be determined by the formula:

$$\left. \begin{aligned} P_x &= \sqrt{P_{lx}^2 + P_{ox}^2} , \\ P_y &= \sqrt{P_{ly}^2 + P_{oy}^2} . \end{aligned} \right\} \quad (4.2.22)$$

**4.2.23** In case where it is impracticable to design the structure for securing the object taking into account the requirements of 4.2.15 and 4.2.17 for separation of functions, the Formulae (4.2.18) have no application and the forces in the sea fastening elements shall be determined on the basis of the general equations of statics, and for the statically indeterminate structures – on the basis of equations considering also structural deformations.

**4.2.24** When designing sea fastening, consideration shall also be given to the strength of the object itself. Prior to securing of an object which is inadequately rigid, the mathematic simulation in compliance with 3.2.4 of the present Part shall be performed. In case where the object is not capable to withstand forces applied to it by the sea fastening elements, the additional restrictions on wave conditions shall be imposed, or strengthening of the object structures shall be provided, or another craft shall be selected, etc.

**4.2.25** The nominal acting stresses obtained by standard structural mechanics and exposed to the above mentioned loads  $P_{lx}$ ,  $P_{ly}$ ,  $P_{ox}$  and  $P_{oy}$  shall be multiplied by  $K_s$  specified in 4.2.4, and the product obtained shall be

compared with the ultimate loads for the materials of sea fastening specified in the normative-technical documentation or certificates.

**4.2.26** The ultimate loads on the materials of sea fastening shall be as follows/The following loads on the materials used for sea fastening shall be adopted as ultimate ones:

for rigid members – specified yield stress of steel elements and welds;

for wood – design strength;

for flexible members –  $0,5 \times BL$  ( $BL$  – minimum value of breaking load of the constituent elements of lashing: chain, rope etc.).

### **4.3 Calculation of towing resistance, selection of towing tactics and calculation of tow lines**

**4.3.1** Generally the towing resistance consists of water, wave, air and tow line resistances. When towing operation is performed in ice conditions the resistance of ice surface shall be added. If the object is provided with a propeller and has appendages the resistance thereof shall be also added. In case of short-line towing, the effect of the tug propeller interference shall be considered.

**4.3.2** All objects are subdivided into three types:

type 1 – object of rectangular or close to rectangular shape (pontoon, floating dock, MODU, etc.);

type 2 – boat shaped object;

type 3 – irregular object.

**4.3.3** The most accurate method for determining the towing resistance is model basin test. Results obtained by prototype re-calculation are less accurate. If use of these methods is impracticable, approximate calculations by the formulae given below may be made.

**4.3.4** Calculation of towing resistance for a type 1 object.

**4.3.4.1** The water resistance which consists of friction resistance and residual resistance may be calculated by the formula:

when the towing speed is not exceeding 5 knots  $R = f\Omega V^{1,83} + \varphi F V^2$  (4.3.4.1-1);

when the towing speed is more than 5 knots  $R = f\Omega V^{1,83} + \varphi F V^{2,3}$  (4.3.4.1-2)

where  $f = 0,17$  – friction coefficient for steel objects;

$f = 0,30 - 0,35$  – friction coefficient for concrete and reinforced-concrete objects;

$\Omega$  = wetted surface of the object (the area of submerged part of two ends, two sides and the bottom), in  $m^2$ ;

$F$  = area of submerged part of midship section, in  $m^2$ ;

$V$  = towing speed, in m/s;

$\varphi$  = residual resistance coefficient, equal to:

30 – for hulls of parallelepiped shape;

25 – for hulls of parallelepiped shape with a cutup in the forward part within the draft at an angle of about  $45^\circ$ ;

- 20 – for hulls with similar cutup in the after part;
- 22 – for hulls of parallelepiped shape with a cutup in the forward part within the draft at an angle of 45° and in the after part within 0,25 – 0,30 of the draft ;
- 17 – for hulls of parallelepiped shape with a cutup in the forward part within 0,25 – 0,30 of the draft and in the after part within the draft at an angle of 45°;
- 16 – for hulls with cutups in the forward and after parts at an angle of 30-35° to the base line.

This formula gives the highest accuracy at the towing speed from 2 to 5 knots.

**4.3.4.2** The wave resistance may be calculated by the formula:

$$R_w = \frac{Bh}{39,2} (\sqrt{61,6/l} \frac{h}{2} + V)^2 \quad (4.3.4.2)$$

where  $h$  = wave height, in m;  
 $l$  = wave length, in m;  
 $B$  = object breadth, in m.

**4.3.4.3** The wind resistance may be calculated by the formula:

$$R_v = C \frac{\rho}{2} S (V \pm V_v)^2 \quad (4.3.4.3)$$

where  $\rho$  = 0,125 kg·f/m<sup>4</sup> – air density;  
 $S$  = projection of the above-water object part on the midship section, in m<sup>2</sup>;  
 $V_v$  = wind velocity, in m/s, + in a head wind, - in a following wind;  
 $C$  = dimensionless factor = 1,0 for wind at an angle of about 30° to CL and = 0,82 in a head wind parallel to CL.

**4.3.4.4** The tow line resistance may be calculated by the formula:

$$R_t = \Delta C K_r c 2l_t D_t \frac{\rho}{2} V^2 \quad (4.3.4.4-1)$$

where  $\Delta C$  = coefficient accounting for decrease of the tow line resistance due to angle of inclination to the horizon  $\alpha$  (refer to Table 4.3.4.4);  
 $K_r$  = 1,2 for wire rope roughness coefficient;  
 $c$  = resistance coefficient for a cylinder of infinite length located normally to flow;  
 $l_t$  = tow line length, in m;  
 $D_t$  = tow line diameter, in m;  
 $\rho$  = 104,5 kgf/m<sup>4</sup> — sea water density.

The coefficient  $c$  may be taken equal to 1,2 for the Reynolds numbers from 10<sup>4</sup> to 2·10<sup>5</sup>.

The Reynolds number shall be calculated by the formula:

$$R_e = \frac{V D_t}{\gamma_k} \quad (4.3.4.4-2)$$

where  $\gamma_k$  = 1,15·10<sup>-6</sup> m<sup>2</sup>/s – kinematic viscosity factor of water.

Table 4.3.4.4

$\alpha$ , in deg.	$\Delta C$
10	0,030
20	0,076
30	0,173
40	0,309
50	0,492
60	0,686
70	0,854
80	0,963
90	1,000

**4.3.4.5** The ice surface resistance during towing may be calculated by the empirical formula:

$$R_i = (C_k + 9V^{1/3})h^{1,2} \quad (4.3.4.5)$$

where  $V$  = average towing speed, in m/s;

$h$  = ice thickness, in m;

$C_k$  = dimensionless factor (refer to Fig. 4.3.4.5).

Fig. 4.3.4.5 shows  $C_k$  —  $r$  (ice extent) diagram.

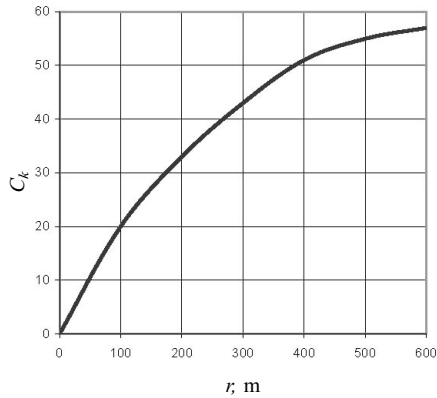


Fig. 4.3.4.5

**4.3.4.6** The effect of propeller interference is accounted for by the following efficiency factor:

$$\alpha_{int} = [1 + 0,0154 A_{exp}/L_t]^\eta, \quad L_t > 30 \text{ m}, \quad (4.3.4.6)$$

where  $\alpha_{int}$  = interaction efficiency factor;

$A_{exp}$  = projected cross-section area of the towed object, in  $\text{m}^2$ ;

$L_t$  = tow line length, in m;

$\eta = 2,1$  for typical barges.

**4.3.4.7** The total towing resistance is a combined value calculated in accordance with 4.3.4.1 to 4.3.4.6.

**4.3.5** Calculation of towing resistance for a type 2 object.

**4.3.5.1** The water resistance  $R$  consists of shape resistance  $R_s$ , friction resistance  $R_f$  and wave resistance  $R_w$  (a part of water resistance the surmounting of which is associated with the power consumption for wave formation during the object movement)

The shape resistance may be calculated by one of the two formulae, depending on the relationship between the towing speed and the first critical speed determined by the following formula:

$$V_1 = 2,8\sqrt{F/l_{ext}}, \quad (4.3.5.1-1)$$

where  $l_{ext}$  = length of hull extremities (length of the object excluding the parallel body).

If the towing speed is less than  $V_1$ , the shape resistance shall be calculated by the following formula:

$$R_s = (4,5F\sqrt{\frac{\sqrt{F}}{l_{ext}}}V_1)V. \quad (4.3.5.1-2)$$

If the towing speed exceeds  $V_1$ , the shape resistance shall be calculated by the following formula:

$$R_s = 4,5F\sqrt{\frac{\sqrt{F}}{l_{ext}}}V^2. \quad (4.3.5.1-3)$$

The friction resistance may be calculated by the following formula:

$$R_f = c_1\Omega V^2, \quad (4.3.5.1-4)$$

where  $c_1$  = coefficient obtained from Table 4.3.5.1 depending on towing speed and hull length  $L$ .

Table 4.3.5.1

$VL$	$c_1$	$VL$	$c_1$	$VL$	$c_1$
40	0,205	400	0,143	4000	0,111
60	0,194	600	0,133	6000	0,109
80	0,187	800	0,128	8000	0,108
100	0,180	1000	0,124	10000	0,107
200	0,159	2000	0,116		

The wetted hull surface area of the boat shaped object shall be calculated by the following formula:

$$\Omega = 1,05L(1,7d + C_{block}B) \quad (4.3.5.1-5)$$

where  $L$  and  $B$  = object length and breadth on waterline, in m;

$C_{block}$  = block coefficient of the object;

$d$  = object draft, in m.

The wave resistance of the type 2 towed objects is so small that it may be neglected in practical calculations.

**4.3.5.2** The resistance from waves, wind, tow line, surface ice and the effect of the tug propeller interference shall be determined in accordance with 4.3.4.2 to 4.3.4.6.

**4.3.5.3** The propeller resistance (if any) shall be calculated for two cases: resistance of fixed propeller  $R_{pf}$  and resistance of free-running propeller  $R_{pr}$ :

$$R_{pf} = 2,24d^2V^2 \quad (4.3.5.3-1)$$

where  $d$  = propeller diameter, in m.

$$R_{pr} = 0,35R_{pf} \quad (4.3.5.3-2)$$

**4.3.5.4** The appendages resistance shall be calculated proceeding from their shape using methods adopted for calculation of resistance of bluff structures.

**4.3.6** The towing resistance of the type 3 objects shall be calculated using methods adopted for calculation of resistance of bluff structures.

**4.3.7** The calculations of the towing resistance are recommended for various towing speed (with a step of 1 knot), wind forces and waves corresponding to these wind forces (for each Beaufort number). Based on these data, in order to select the best relationship it is recommended to plot a towing resistance curve depending on towing speed and weather conditions.

**4.3.8** The design towing resistance shall be increased by 20 per cent (to maintain maneuverability due to weather deterioration), and this result shall be considered as the required bollard pull for marine operation performance.

**4.3.9** The composition of the tow order vessels shall be determined, based on the required bollard pull and bollard pull of the tugs which are planned to be involved in the marine operation.

**4.3.10** The tug bollard pull shall take account of reduction of the bollard pull in waves.

Unless more accurate calculations are made, the continuous bollard pull stated in the ship's documents shall be multiplied by the following efficiency coefficient:

0,85 – in closed seas (the Baltic Sea, the Caspian Sea, etc.);

0,75 – in open seas (the Sea of Okhotsk, the Sea of Japan, the Barents Sea, etc.).

**4.3.11** The tow line parameters depend on the number of tugs and the bollard pull value of each tug and shall be consistent with the requirements of Part III "Arrangements, Equipment and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships.

**4.3.12** The towing arrangements of the towed objects shall comply with the requirements of Section 5, Part III "Arrangements, Equipment and Outfit" of the Rules for the Classification and Construction of Sea-Going Ships. If it is impossible to make calculations in compliance with the above requirements, the calculation of the towing arrangement shall be submitted to the Register for approval.

**4.3.13** The need for using auxiliary escort or assisting tugs shall be established in designing marine operation proceeding from complexity of the tow route, existence of narrow waters, expected adverse weather conditions, etc.

**4.3.14** During towing, the tow line length, the action of each tug and escort tug shall be defined by the manager of the towing stage of marine operation, proceeding from actual conditions.

## **5 LAUNCHING**

### **5.1 General**

**5.1.1** A launching operation represents a sequence of stages from initiation of the launch to the stage where the barge and object float separately.

**5.1.2** Launching is made possible by the following methods:

by ballasting of the transport pontoon and, where necessary, buoyancy pontoons and by moving the object aside;

by ballasting of the transport dock and by moving the object out through the stern gate of the dock;

longitudinal launching from a launch barge with the use of symmetrical aft rocker arm, e.g. for the truss-type substructure.



The requirements of this Section apply in full measure to the longitudinal launching. For launching by means of ballasting, use shall be made of the applicable provisions of this Section.

**5.1.3** Launching from multi barge system with unsymmetrical launch frames, sideways sliding of piles and separate object elements is subject to special consideration by the Register.

**5.1.4** The following parameters shall be considered in relation to operational feasibility and structural limitations for the launched object and of the barge:

- size and buoyancy and stability characteristics of the object;
- barge size;
- position of the object on the barge;
- barge draft;
- barge heel and trim;
- barge bending moment;
- barge submersion;
- position of ballast water in the barge;
- limiting environmental conditions;
- rocker arm arrangement and rotational limitations;
- allowable rocker arm reactions;
- friction coefficient during launching;
- water depth on the launching site;
- auxiliary buoyancy.

**5.1.5** Prior to start preparations for launching, it is necessary that the weather forecast shall be for the steady weather progress with the weather being invariable throughout the planned operation duration. The decision to initiate launching shall be based on the forecast window suitable for completion of all the object positioning operations, including acceptable margins for unforeseen cases. The object may be considered safe when it is capable to withstand an extreme storm which occurs once every ten years. Therefore, both the operation manual and the schedule shall confirm that the extreme conditions can be withstood throughout the operation, after the decision on launching was taken.

**5.1.6** The launching operation shall be performed in specified area which is subject to hydrographic survey confirming that the area concerned is free of any obstructions. It is not recommended to perform launching over subsea pipelines, underwater facilities or other underwater obstructions.

**5.1.7** The calculations made shall show that the launched object will behave in a stable manner during the launching operation. Model tests shall be used for verification of the object's behaviour and evaluation of forces acting during

launching, especially when launching is performed in shallow waters and at low reserve buoyancy.

**5.1.8** The trajectory of the launched object shall normally be computed by a dynamic analysis. The analysis shall include assessment of the barge motions.

All significant forces influencing the behaviour of the barge and launched object shall be considered. Particular attention shall be given to the behaviour of the barge and the effect of resulting uplift forces from the rocker arm onto the launched object.

**5.1.9** The basic loadcase shall be analyzed distributing the self weight, buoyancy forces, barge foundation/support forces to the structural elements of the launched object and barge.

**5.1.10** Loading effects from wind, motions due to waves and movements/displacements of the object and barge during the launching operation shall be considered. The resulting increase in hydrodynamic forces may be accounted for by use of a dynamic amplification factor on the static forces.

**5.1.11** When analyzing launching, consideration shall be given to damage of any one compartment of the object with the design hull weight and CoG position.

## **5.2 Requirements for the launched object**

**5.2.1** The design weight and buoyancy of the object shall be determined using drawings along with physical weighing of components. Potential inaccuracies in the determination of the buoyancy shall be included into the allowance used for the design weight in the object analysis.

The allowance in the analysis, used for the object weight, shall be at least  $\pm 3$  per cent (including inaccuracies in determining buoyancy).

The allowance in the analysis, used for the CoG position of the object (including inaccuracies in the CoG position), shall be at least:

$$X \pm 0,3 \text{ m};$$

$$Y \pm 0,3 \text{ m};$$

$$Z \pm 1,0 \text{ m},$$

where  $X$  and  $Y$  are horizontal axes and  $Z$  is a vertical axis for the final orientation of the object.

The above allowance shall be used in final analysis, when the whole material for the structures is put in production. Smaller allowances may be used if they are established on the basis of accurate weighing. It is recommended to take account of the greater unaccounted weight at the early design stages considering uncertainties which decrease progressively.

The analysis of the launching acceptability, to be made, shall consider at a time change of only one of the above allowances:

change of the weight and CoG position shall not be considered;

the CoG position shall change only in one direction ( $X$ ,  $Y$ ,  $Z$ ).

**5.2.2** The object shall be equipped with sliding cradle.

**5.2.3** When launching, consideration shall be given to the following sequence of loads acting on the object:

self weight;

buoyancy;

braking (friction);

barge/rocker arm reactions;

inertia forces.

**5.2.4** The resultant loads in each element of the object shall be calculated in discrete time during launching. So, e.g. the enveloping load shall outline each element and compare the maximum load with the allowable value.

The effective values of the self weight, CoG position and friction coefficient may be known only within certain allowances. The load elements shall be determined with consideration for the maximum possible allowances and thereafter correlated with the allowable values.

Some structural components may be subjected to impact loads during launching operation, which shall be taken into account in compliance with 5.1.7 and 5.1.8. Stresses due to hydrostatic loads when the object is submerged during launching shall not exceed the allowable stresses. The pressure of a water head for calculation of the maximum allowed depth for each element during launching shall be taken with a margin.

**5.2.5** The launched object shall have sufficient strength to withstand the loads acting on the object during launching, especially at the time of turning on the rocker arm and at the initial moment of entry into water. Special attention shall be paid to local support loads and loads acting on the launch frame including consideration of the properties and fabrication tolerances of the launch timber. The buoyancy and stability of the object shall comply with 1.2.2.3 of the present Part.

**5.2.6** Preferably all watertight structures having positive buoyancy, e.g. supports with positive buoyancy or buoyancy pontoons, shall have a small internal overpressure at departure from shore. Provision shall be made for monitoring pressure inside such structures from a readily accessible position.

### **5.3 Requirements for the barge**

**5.3.1** The barge shall have sufficient positive intact stability and the necessary reserve buoyancy at all stages of launching operation in compliance with the requirements of 1.2.2 of the present Part considering the behaviour of the object during the operation. The transverse metacentric height shall exceed 1 m throughout the period from the initiation of the launch to the end of the

rocker arm rotation. The depth of the barge stern submersion shall be within the range of permissible limitations at all times.

**5.3.2** The loads on the barge shall be verified to be within the operational limitations assessed by the classification society the barge classified with. This verification normally includes evaluation of:

- bending and torsion of the barge hull;
- rocker arm reactions;
- barge submersion;
- barge hydrostatic stability;
- compliance with the special requirements of the classification society.

Strengthening shall be subject to acceptance by the classification society the barge classified with.

**5.3.3** Any structural components on the barge not assessed by the classification society the barge classified with shall be verified to have sufficient global and local structural strength to withstand all loads during launching operation. Such structural components may include launching ways, positioning brackets for attachment of positioning lines, attachments for winches, hydraulic jacks, sheaves, etc.

Rigging equipment shall be connected to attachment points (lugs, trunnions, bollards, etc.) especially designed for the corresponding loads. Other attachment points shall not be used.

**5.3.4** The barge ballasting system shall have sufficient capacity to achieve the predetermined barge launch parameters within a time period not exceeding 25 per cent of the favourable weather forecasting period.

**5.3.5** The ballast tank volume shall have sufficient spare capacity such that the required trim, heel and draft can be maintained in the event of accidental flooding of any one compartment.

The barges shall be equipped with means to monitor the barge trim and water level in the ballast tanks.

Hatch covers over barge tanks shall not be open prior to or during launching, and when using submersible pumps.

**5.3.6** The power supply on the barge shall have sufficient capacity for lighting during night work, welding and flame cutting operations.

**5.3.7** The flame cutting facilities shall have sufficient capacity for cutting of the seafastening elements within a time period not exceeding 25 per cent of the favourable weather forecasting period. Sufficient number of workers and equipment items shall be provided to perform such operation.

**5.3.8** The object to be launched shall be secured to the barge with anti self-launch devices to prevent a spontaneous premature launch after cutting of the seafastening elements.

**5.3.9** Anti self-launch devices shall have sufficient structural strength to withstand the horizontal gravity component due to barge trim. Friction may be considered provided the lowest expected dynamic coefficient of friction is used together with conservative values for both static and dynamic barge trim (refer to Table 3.8.7 of the present Part).

**5.3.10** The launch initiating push/pull system shall have sufficient capacity to overcome the static friction forces, and shall be capable of applying this force over a sufficient distance to ensure initiation of the launch.

**5.3.11** The sliding surfaces shall have a finish that assures a relatively low coefficient of friction.

**5.3.12** The launching appliance (power units, winches, slings, shackles) shall have sufficient working load, be fit for its intended purpose and arranged so as to:

- ensure short start-up time;
- avoid damage to the object during launch;
- allow for possible object yaw during launching by the guiderails on the rocker arms.

**5.3.13** The barge including all permanent equipment and systems and auxiliary equipment and systems to be used during the launch operation shall be inspected and/or tested prior to departure from shore. The tests/inspections shall verify that the equipment and systems are in good working order, comply with the requirements of the classification society the barge classified with and fit for the intended use.

**5.3.14** A survey of the launching ways and rocker arms shall be performed to verify that the alignment and level is within the criteria considered in the structural verification of the barge and the launched object.

#### **5.4 Operational aspects**

**5.4.1** A launching operation control station shall be provided. The control station shall be equipped to obtain the whole information on the operation procedure.

**5.4.2** The barge shall be positioned by lines attached to the tugs and relative to a set of predetermined coordinates to ensure that the launched object will not hit the seabed or structures positioned on the seabed.

The barge heading for launch shall, where possible, be into the prevailing wind and wave direction.

**5.4.3** The following conditions shall be complied with before starting the cutting of seafastening and/or ballasting of the barge:

- the environmental parameters correspond to the design ones;
- the launch position and orientation has been found acceptable;
- all structures and equipment necessary for the launch operation are correctly rigged, ready to be used, and have been inspected and tested;

means which ensure the structure resistance to extreme seasonal weather conditions after installation are ready to be used;

obstacles which may unduly delay the operation have been removed.

**5.4.4** Seafastening elements shall be cut in accordance with a predetermined procedure containing a number of steps. The cut lines shall be painted. Continuous watch on the weather conditions, including the weather forecast shall be performed. The point of no return shall be identified in the procedure.

Seafastening elements that have been cut shall be secured to the barge to avoid interference with the object during launch. After cutting of the seafastening element and prior to ballasting of the barge, it is recommended to initiate the object movement by the use of the push/pull system or launch initiation system.

**5.4.5** When removal of the seafastening elements is finished, the barge shall be so ballasted as to achieve the trim necessary before the launch. By the time of completing of the barge trimming, the crew on board shall be reduced to the minimum required number that will allow to exercise control over the launching operation.

During launching the object shall be free from any obstructions. If any lines comprise the object's rigging before the launch, it shall be proved that they will not get foul of the obstacles during the launching operation.

**5.4.6** The launch shall be initiated in a controlled manner by removing the anti self-launch devices and/or by pushing/pulling the launched object to overcome the static friction forces.

Tugs shall not be used to initiate the launch.

**5.4.7** The lugs and similar structures shall have sufficient structural strength to overcome the maximum static friction forces and ensure self-release of the pulling lines.

**5.4.8** The launched object shall be connected to positioning and hold-back ships, by lines with sufficient slack to allow free movement during the launch.

**5.4.9** The number of tugs shall be sufficient to hold the object after launching, and, as a minimum, one tug shall be permanently connected to the barge (in the forward part).

**5.4.10** The following parameters shall be monitored and recorded during preparations for launch:

- barge trim and draft;

- barge position and orientation;

- barge motions;

- barge ballast and stability parameters;

- draft, heel and trim of the object after launch.

## **5.5 Upending**

**5.5.1** Upending of the object may be required when the object is towed in horizontal position or when it is transported on the barge and launched in the same position.

**5.5.2** Upending operations shall be carried out by controlled ballasting and deballasting of buoyant compartments.

Upending operations assisted by crane lifting, and the necessary reserve buoyancy in this case are subject to special consideration by the Register.

**5.5.3** An upending operation represents a sequence of different loadcases from the initial self-floating condition to the final self-floating condition (installation).

The basic loadcases shall be analyzed by static analysis considering the buoyancy, self weight and any loads applied during upending.

**5.5.4** Loads on buoyant compartments shall be calculated for the largest submergence draft considering accidental flooding of any one watertight compartment.

**5.5.5** Upon completion of the upending operation the object shall remain afloat in stable equilibrium and with sufficient freeboard to allow commencement of positioning and setting operation.

**5.5.6** Structures shall have sufficient strength to withstand the loads described in 5.5.3 and 5.5.4.

**5.5.7** The ballast system including the buoyancy tanks connected to the ballast system shall be designed such that the upending operation may be suspended and reversed at any stage. It shall be taken into account that there is normally a moment in the process when the operation comes out of control. Such situation takes place when the waterline area is drastically reduced during rotation (at the large tilt angles) and the object continues its rotation without additional ballasting. The same situation takes place in the reverse operation.

The upending sequence shall clearly identify such "points of no return".

The ballast system shall be designed so that the object remains afloat in stable equilibrium except for the situation described above.

**5.5.8** The ballast tanks shall, where possible, be designed such that they are flooded uninterruptedly by 100 per cent

**5.5.9** When carrying out ballasting operations, the following parameters shall be monitored manually or by remote monitoring system:

- draft, trim and heel;
- seabed clearance;
- environmental conditions;
- amount of water in the ballasting compartments;
- open/close mode for valves;

air pressure in tanks;  
ballasting rate;  
crane hook load.

**5.5.10** Two separate methods shall be available for the starting or stopping of flooding of anyone independent compartment. Where requirements in 5.5.8 are satisfied a back-up method of halting flooding may be omitted.

**5.5.11** The minimum seabed clearance of an intact structure shall be 5 m in deep water and 10 per cent of water depth (from the lowest level) in shallow water considering displacements due to motions, heel due to current and towing forces, general inaccuracy, possible overloading of hull and sea level variations due to barometric pressure variations.

The seabed clearance shall be positive when any one compartment is damaged. To fulfill the said requirement a clearance of minimum 2 m shall be available. In special cases, e.g. in shallow waters, the clearance may be reduced.

**5.5.12** The hook load of a crane shall be determined on the basis of ballasting calculation. The accidental flooding during the crane operation shall not cause an uncontrolled overturning of the object or interfere with the sling release.

It may be assumed that an occasional flooding during upending of the object by hook shall be sufficiently slow and provide the crane operator with a better possibility of avoiding overloading of the crane by means of slacking of the line. In this case, the hook load may be increased. The resultant loads and stresses due to hook loads shall be evaluated and added to the loads due to self weight and buoyancy.

The effect of the crane ship on the object displacement characteristics shall be considered when analyzing displacement.

The design shall contain calculation of the additional resultant loads of the crane depending on the upending procedure.

A horizontal clearance of minimum 3 m shall be available at all times between any part of the crane ship and the object. A horizontal clearance of minimum 3 m shall be normally available between the crane ship and the cargo barge, but it may be reduced provided that the adequate fendering protection is used.

## **6 INSTALLATION OF THE OBJECT ON SITE**

### **6.1 General**

**6.1.1** For the purpose of these Rules, the term "installation of the object in a design position" (hereinafter referred to as "object installation") is considered to mean a sequence of activities, procedures, control checks and corrective actions



that ensure safe transfer of the object from transportation position to one as designed which is resistible to external effects during the entire time the object being in the above position.

Installation of the object includes:

construction of the working site;

positioning of the object over the installation site and orientation thereof in space;

submersion of the object;

securing of the object to the seabed (by piling or by gravity, installation of position mooring system);

mating of the object parts (if applicable).

**6.1.2** Position of the installation site shall be established in the marine operation design (or work performance design).

When developing the installation design, consideration shall be given to the following:

compliance with the prescribed allowable deviations;

prevailing current directions;

actual possibilities of using technical means as applied to the structural limitations for the object;

scope and productivity of ballasting operations;

need for monitoring the object position by means of divers and/or remotely operated vehicle (ROV), and the time period when such monitoring shall be performed, as well as the duration thereof.

**6.1.3** The marine operation operator shall monitor the execution of the operation and shall be sure that the tolerances for installation of the object are maintained throughout each installation phase.

**6.1.4** When preparing the installation site, provision shall be made for sufficient tolerances which account for the inaccuracies of:

positioning;

instrumentation used during installation;

other errors.

**6.1.5** Unless expressly provided otherwise, the objects shall be installed under sea conditions with the following accuracy:

center of the object within a circle with a radius of 7,5 m with its center at the design position point;

CL within  $\pm 1^\circ$  of the design direction;

base line within  $\pm 30$  cm from the theoretical elevation;

heel and trim: all angles shall be corrected within  $\pm 7,5$  cm from the final lift of the central point.

**6.1.6** Unless expressly provided otherwise, the objects attached to the existing structures shall be installed within the following tolerances:

foundation center shall be within a circle with a radius of 1 m with its center in the theoretical coordinates given in the drawings:

orientation  $\pm 1^\circ$ ;

lift at center  $\pm 30$  cm;

lift at corners  $\pm 7,5$  cm.

**6.1.7** Particular attention shall be paid to the FOP topside/modules lifting. The following requirements shall be established for these operations:

angle between the main-deck beam being installed and the top surface of the substructure is less than  $0,5^\circ$ ;

rise of the deck plating at the center within  $\pm 3$  cm above the design level;

deck angles shall be corrected within  $\pm 12$  mm of the actual deck plating rise at the substructure center.

**6.1.8** Boat landing area for disembarkation from the craft shall be checked during falling tide. The position shall be within  $\pm 30$  cm of the design one.

**6.1.9** When performing installation operation, it is recommended to use special equipment which provides a reliable and regular monitoring of the object positioning. The equipment may be of hydroacoustic and/or optical and/or radioelectronic type.

The accuracy of measuring instruments shall be consistent with the installation tolerances.

**6.1.10** It is recommended that the equipment necessary to monitor the installation of the object includes the following items (but not limited to them):

hydrolocators for sea floor survey;

optical system operating from fixed points, or lidar for topographic survey without regard to the curvature of the Earth;

distance measuring system for accurate measurement of distance;

optical (or laser) level measurement equipment ;

wave meter and tide recorder.

Measurement results shall be recorded and kept.

**6.1.11** Provision shall be made for a system capable of providing continuous monitoring of the position and orientation of the object in relation to the desired position (beacon), as well as a second (independent of the first system) system intended to duplicate and monitor the primary system.

It is recommended to monitor and record the object installation process by means of ROV or pre-installed TV cameras.

**6.1.12** Prior to submersion, the object shall be oriented to the design position by means of ships or pre- installed mooring buoys.

## **6.2 Construction of the working site**

**6.2.1** Construction of the working site shall be carried out before the installation of any object and include the following operations:

- seabed survey and removal of obstacles both on and in soil strata, presence of which is not allowed;

- removal, where necessary, foul holding ground, silt, etc.;

- layout of good holding ground (if necessary).

**6.2.2** The design of setting down the object on the seabed shall be based on the results of the scanning survey which shall be carried out to verify that the site is free from underwater obstructions and the water depth is sufficient.

Such survey shall also cover investigation of the seabed soils, especially in cases when skirts on fixed objects or piled structures are used.

**6.2.3** In the process of the installation site preparation, the slit and non-uniformity of the seabed, and any other seabed obstacles which are likely to damage the bottom structures of the object, in particular, sunk large-sized structures, deris, boulders, etc. shall be removed.

**6.2.4** Status and contents of documents developed in the work performance design shall be established by the firm responsible for the work or by prime contractor, based on the specific character and scope of the work to be performed.

**6.2.5** The design documentation shall reflect issues concerning:

- navigational equipment and recommendations for underwater survey of the installation location;

- site preparation procedure;

- composition of technical facilities and equipment for site preparation;

- composition of technical facilities, equipment and instruments for underwater engineering works and diving operations;

- object installation accuracy;

- tolerances for geometrical parameters of the site;

- safety measures to be taken during site preparation;

- safety measures to be taken during diving operations.

**6.2.6** Working site construction design shall include the following documents:

- .1 Major construction solution:

- site plan of the object installation;

- explanatory note containing the following Sections:

- general;

- design decisions;

- work performance requirements;

drawings (object installation plan, plan of substructure and its general view with indication of dimensions, physical and mechanical properties of the seabed basis).

The site plan shall show the existing piping and underwater obstructions, as well as areas where anchoring is prohibited;

.2 decisions taken on work organization:

methods of performing basic construction and assembly operations (general provisions, preparatory period, basic provisions for construction arrangement);  
instrumental monitoring;

safety measures;

demand for basic machinery and ships (types, number);

.3 Appendices (equipment technical passports and ships' files).

**6.2.7** In order to prevent significant non-uniformities of the soil pressure on the lower surface, as well as object inclination, the installation site of a fixed object shall have a plane horizontal surface. The value of allowable seabed roughness and object inclinations shall be determined during design.

**6.2.8** Site survey shall be carried out in compliance with 3.10 and 3.11, Part II "General Requirements" of these Rules and the requirements of the regulating and technical documents of the Russian Federation.

### **6.3 Positioning**

**6.3.1** The object shall be installed in a design position and kept in this position by own anchors, auxiliary ships, mooring buoys (pre-installed) or combination thereof.

**6.3.2** The technical facilities shall ensure position keeping of the floating object within the limits specified in the design under design hydrometeorological conditions specified by the design, but not less than the following:

design wave height with 3 per cent probability of exceeding level – not less than 2 m;

design wind velocity — not less than 10 m/s.

**6.3.3** For better object orientation in relation to subsea structures available at the working site, these structures are recommended to be marked with clearly visible buoys.

**6.3.4** To monitor object position in relation to the end section of subsea pipeline, these structures are recommended to be clearly marked.

### **6.4 Submersion and setting down**

**6.4.1** The method of object submersion (on an even keel or with a heel/trim) shall be determined in the marine operation design.

**6.4.2** The following parameters shall be considered in evaluation of the operational feasibility:

limiting environmental conditions;

time limitations determined by the weather window;  
structural limitations for the object;  
ballasting system capacity;  
object buoyancy and stability;  
soil characteristics and on-bottom stability.

**6.4.3** The ballasting system shall ensure:

submersion rate, primarily, when the substructure approaches the seabed, that prevents impacts upon the seabed which may cause damages to the substructure, especially, to the skirt, if any;

generation of required clamping force to ensure on-bottom stability when the object is exposed to external loads during installation until it is finally fastened;

capability of the object alignment in a horizontal plane by asymmetric ballasting considering soil parameters and seabed topography.

**6.4.4** When submerging the object on an even keel, the procedure for filling ballast tanks shall be provided that ensures safe submersion of the object without any excessive heels/trims. For this purpose, provision shall be made for simultaneous filling of tanks located symmetrically relative to the substructure center. Estimated correction for the metacentric height due to free surface effects simultaneously in two ballast tanks shall be provided.

**6.4.5** In order to avoid free surface effect in the ballast tanks provision shall be made for prevention the situation when with two slack ballast tanks the next pair of tanks is being filled. Filling of this pair of ballast tanks shall be only commenced as soon as preceding tanks have been topped up.

**6.4.6** The ballasting plan shall contain a graphical chart showing the metacentric height variation during the object submersion and possible heels/trims (under the design wind and wave conditions), and a suitable equipment shall be provided for monitoring thereof. Particular emphasis shall be placed on the moment of abrupt change of the waterline area which may cause a drastic increase in heel/trim.

**6.4.7** Where skirts are available, to avoid effect on the soil surface and formation of obstructions on the outside of the skirts, the side drift of the object shall be prevented. These obstructions may block the skirt penetration into the seabed. This operation shall be monitored to avoid pore water overpressure (pressure excessive in relation to hydrostatic pressure arising in the seabed soil saturated by sea water due to soil stabilization) inside the skirt elements which may result in local seabed erosion.

**6.4.8** Lines used in the object installation shall, where possible, be attached to the object structures located above the final waterline and easily released (step-by-step).

**6.4.9** Provision shall be made for a deballasting plan in the event of not precise object setting on the seabed, upfloat and re-ballasting.

**6.4.10** If the ballast tanks are filled not by own pumps, but by delivery of water from the supply vessels, the arrangements shall be provided on the object deck enabling to connect the hoses from the supply vessels to the object ballast system.

**6.4.11** After touching the seabed the object shall have sufficient on-bottom stability against overturning or sliding of the structure due to environmental loads before ballast intake and/or pile driving are obtained. On-bottom stability after touching shall be verified by calculations for the absence of shift and uplift of the periphery from the seabed for weather conditions required for the operation. The same calculations shall be made for the weather conditions which may occur in case of delays or unforeseen events which prevent timely intake of the main ballast, i.e. filling of pontoons and/or other parts of substructure.

**6.4.12** A person who is a member of the key personnel, familiar with the peculiarities of the submergence operations, has experience in similar operations (e.g. dockmaster of floating dock) shall be responsible for the performance of submergence operation. All these operations shall be executed only after the approval has been granted by the above person or at his command.

**6.4.13** Object position monitoring during submersion may be performed using GNSS or by checking points.

**6.4.14** The operation design shall specify the requirements for:

- disposition and positioning of ships and sequence of the operation;
- equipment of mooring and anchoring arrangements with line tension monitoring systems;
- composition of positioning systems;
- facilities to monitor the object displacements, draft, heel and trim;
- means of communication between the control centre, control stations and ships;

activities of persons involved in the operation under changed hydro-meteorological conditions, in the event where the parameters of environmental effects exceed the design ones and in accident situations.

**6.4.15** After the object have been set down on the sea bed/cushion, the underwater survey of its actual position shall be carried out, which shall include (if applicable) measurements of the relative position of the object and end portion of the subsea pipeline or other pre-installed objects. Based on the results of underwater survey, an appropriate report shall be drawn up, and the operation shall be considered as completed if the actual measurements are within the design tolerances.

## **6.5 Fixing of the object at the installation site**

### **6.5.1 Piling.**

**6.5.1.1** Selection of the pile driving equipment shall be based on a calculation.

**6.5.1.2** The following parameters shall be established by the calculation:

pile driving resistance of soil;

check for proper selection of the hammer for pile driving down to the required mark or the pile bearing capacity;

maximum dynamic compressing and tensile stresses in cross-sections along the pile length due to hammer blow;

determination of the failures during driving;

determination of the pile capacity based on the results of measurements of and elastic displacement of pile head due to hammer blow during driving.

**6.5.1.3** The pile driving calculation shall be based on the wave theory of impact. The computer calculation programs recommended by the Rosstroy (RAM-2, DIZO-2) or similar foreign programs may be used for calculation.

**6.5.1.4** The soil resistance may be determined by means of the design tabulated soil resistances in accordance with SNiP 2.02.03-85\* or from the physical and mechanical properties of the soil (internal resistance factor, adhesion, density, etc.) in accordance with the algorithm for sandy and clay soils.

**6.5.1.5** The maximum dynamic stresses during driving of piles shall not exceed 0,9 of the pile material yield strength.

**6.5.1.6** The failure parameters during driving of piles (minimum pile penetration at a certain number of drive blows) shall be specified by the designer, but under no circumstances they shall be less than those indicated in the hammer specification.

**6.5.1.7** Arrangements shall be made to cover initial failure when penetration is less than the design one (soil erosion, drilling over). Penetration of the pile which is less than the design one may be permitted only upon agreement with the designer of piling.

**6.5.1.8** The object on-bottom stability shall be ensured during driving of piles when the object is subjected to the design external loads. If necessary, temporary ballasting of the object shall be provided.

**6.5.1.9** As a minimum, the following information shall be documented for each pile to be installed:

pile number and support position;

date and time of driving;

penetration due to self weight of the pile and weight with the pile-driving hammer stabbed on top of the pile (and with spacer pile, if applicable);

pile penetration depth;

drive blow counts (number of blows for each 250 mm of pile penetration).

**6.5.1.10** Upon completion of pile driving, object position and verticality shall be verified.

**6.5.1.11** Piles shall be secured in the pilesleeves by the method specified in the design – by grouting, expansion of piles in the guide grooves (method HYDRA-LOCK), swaging of piles, welding. The securing procedure shall be submitted to the Register for consideration.

**6.5.1.12** Requirements for the procedure of the pile head grouting in the substructure pileslots:

**.1** fast-hardening portland cement shall be used for making up the grout mix;

**.2** the grout supply system shall be capable of filling the clearance between the pile and pileslot without any free space;

**.3** it is recommended to carry out grout supply pipe assembly during the object manufacture;

**.4** closed grouting system with installation of seals to isolate the water annular is preferable;

**.5** during grouting the amount of grout mix shall be monitored by means of regular measurement of the grout mix density in the grout mixing plant prior to injection and in the clearance;

**.6** during grouting reference specimens shall be made to determine concrete strength in accordance with GOST 10180-90 (4 specimens per pile). Reference specimens during hardening shall be kept under the same conditions wherein the grout in the annular clearance of the pile connection gains strength;

**.7** arrangements shall be made for unforeseen situations:

cementation when the clearance is filled incompletely, e.g. in the event of the concrete pump failure;

clearance seal failure in the upper and lower parts with the grout leaking;

chocking of the grout supply pipes;

**.8** arrangements shall be made to prevent marine pollution.

## **6.5.2 Gravity penetration.**

**6.5.2.1** Gravity penetration into the seabed is achieved by adding weight to the object by water and solid ballast intake.

**6.5.2.2** The pore pressure indicators shall be provided. The required amount of the water and solid ballast shall be determined to ensure clamping force.

**6.5.2.3** Where solid ballast is loaded, a special group of tanks intended only for clamping force generation, and the sequence of filling thereof which makes it possible to simplify control of the amount of water taken shall be determined.



**6.5.2.4** Where solid ballast in the form of a flow concrete mix that fills the object compartment is loaded, the work performance design shall take account of:

- arrangement of equipment for making up concrete mix;
- procedure of delivery, storage and inspection of direct materials prior to use;
- moist curing of concrete, which define production of a durable structure.

**6.5.2.5** The requirements for solid ballast placement are given in Appendix 3.

**6.5.3 Installation of position mooring system for floating objects.**

**6.5.3.1** The position mooring system shall be installed in the following sequence:

- anchor positions shall be determined;

- anchors with attached bridles and buoys marking anchor positions shall be installed;

- bridles shall be laid from each anchor to floating object and attached thereto;

- anchor with high holding capacity shall be tightened up and thereafter position of anchors and bridles shall be verified.

**6.5.3.2** In case where position mooring system is installed in the area with water depth exceeding 60 m and with pre-installed offshore structures, it is recommended that the design clearances determined with consideration for environmental impact on the object and breakage of one anchor line are not less than the distances from those structures to the position mooring system elements given in Table 6.5.3.2.

When synthetic fiber ropes are used, clearances shall be particularly determined for each case. They depend on the system geometry under environmental load variation and on the effects of contact between the anchor line and offshore structures.

The lines of synthetic fiber ropes shall touch the seabed neither during installation nor in operation.

The minimum clearances from structures on the seabed given in Table 6.5.3.2 are valid for drag anchors. For other types of anchors (without substantial dragging) lesser clearances may be accepted.

The customer may establish more stringent requirements for the clearances.

For sea depths less than 60 m, after detailed review of the position mooring system characteristics and effects of failures or wrong actions, less stringent requirements than those proposed in Table 6.5.3.2 may be accepted.

**6.5.3.3** Other types of anchors shall be installed within the tolerances specified in the design documentation.

In case where piles are used as anchors, bridles may be attached to them with the help of divers and laid with the help of supply vessel.

Table 6.5.3.2

**Minimum distances from the position mooring system elements  
to the structures upon completion of installation**

Structures	Direction of anchor lines	Distances to structures	
		Vertical	Horizontal
On the surface			
Floating and fixed objects or two floating objects	—	—	b) 10m
Submerged			
Anchor lines of objects in operation	Any direction	a) 10m b) Without contact	a) 10m b) Without contact
Anchor lines of objects taken out of operation	Any direction	a) 5 m b) Contact is acceptable	a) 5 m b) Contact is acceptable
Anchor line and unprotected pipeline/flexible drill stem	Pipeline crossing	a) 10 m b) Without contact	—
Anchor line and protected pipeline/flexible drill stem	Pipeline crossing	a) Without contact b) Contact is acceptable	—
Anchor line and subsea structure	Crossing of subsea structure	—	Crossing is generally unacceptable
Anchor line and subsea structure or unprotected pipeline/flexible drill stem	Without crossing (parallel)	—	150 m
Anchor line and protected pipeline/flexible drill stem	Without crossing (parallel)	—	50 m
Anchor and subsea structure or fixed object	Any direction	—	300 m or 50 m <sup>1,2</sup>
<sup>1</sup> Provided that the anchor is installed by means of ROV. <sup>2</sup> If the anchor dragging sector is located out of the structure. a) In case of intact position mooring system with consideration for the object shifting due to design environmental loads. b) In case of one anchor line breakage and object shifting.			

**6.5.3.4** Additional requirements for installation with reinforced-concrete mooring anchors:

**.1** such installation shall be carried out in accordance with specially developed procedure approved by the Register;

.2 positions of the mooring anchors shall be checked by divers or ROV;  
.3 central ring of the mooring anchors shall not be in "underneath" or "sidewise" position at which the anchor practically loses its holding capacity. The ring shall lie in the bridle plane to avoid occurrence of excessive bending stresses in operation.

.4 in order to give to the anchor correct position it shall be lifted by the bridle above the seabed and embedded into the soil smoothly;

.5 since the bridle length always exceeds its portion laying on the seabed while in working position, of about a value equal to the sea depth, so when laying bridle, a bend (a half-loop) shall be made at the end of laying in order the bitter end of the bridle does not get entangled with the bridles of adjacent anchor lines;

.6 prior to completion of bridle laying (moment of half-loop formation) the anchor holding capacity shall be checked through testing it by tension with the use of a tug. It will be practicable for bridle laying to use a tug on the deck of which the completely retrieved bridle may be stowed.

Anchor holding capacity may be by slinging the bridle on the ship and by engine operation to produce pull corresponding to design load on the anchor. In case where during 15 min the anchor does not creep, the laying of the bridle shall continue until its full length is slipped. The case of considerable design load and insufficient tug power is subject to special consideration by the Register;

.7 bridle end shall be marked by a buoy with a hauling line so that with its help the bridle can be subsequently lifted for connection to the object.

## **6.6 Mating of objects or parts thereof afloat**

**6.6.1** Mating of the objects or parts thereof afloat (hereinafter referred to as "mating") on high seas is concerned with the operations of joining the topside or topside modules and the substructure together.

In so doing, the following shall be performed:

ballasting of the objects and transport facilities;

positioning;

alignment of the structures to be mated;

setting of the topside on the substructure or floating-up of the substructure.

**6.6.2** The following parameters shall be considered when designing the mating operation:

limiting environmental conditions;

time limitations determined by the weather window;

structural limitations for object and barges;

ballasting system capacity;

buoyancy and stability;

skew loads and whether the skew loading effects remain as permanent after completion of the mating or not.

**6.6.3** Adequate protection of the object against impact loads shall be ensured.

To avoid damages, the Register-approved guides, shock absorbers and compensators based on steel springs, hydraulic/pneumatic damping systems, block pulley, etc. shall be adopted.

The compensator shall be of safe design and certified materials

**6.6.4** Sufficient freeboard to any open compartment shall be ensured during all stages of joining objects considering the consequences of its accidental flooding.

For mating operation where the reserve buoyancy is small, any open separate compartment is recommended to temporarily closed.

**6.6.5** The basic loadcases for the topside and the substructure shall be determined by evaluating the following activities:

ballasting of the substructure to mating draft (or setting of the substructure on the seabed in accordance with the requirements of 6.4 and 6.5);

positioning of the barge with the topside thereon above the substructure;

submersion of the barge or floating-up of the substructure until the topside comes into contact with the substructure;

topside weight transfer from the barge to the substructure by continuing to perform ballasting/deballasting operations;

ballasting of the substructure to design draft (if applicable).

**6.6.6** The basic loadcases may be analyzed as static ones and determined by loads from:

**.1** for the substructure:

external/internal hydrostatic pressure;

ballasting of the substructure;

topside (topside module) weight;

**.2** for the topside (topside module) on the barge:

transfer of the topside self weight from the barge to the substructure;

ballasting of the barge.

Additionally, positioning and mooring loads acting on the substructure or the deck on barges shall be considered.

All realistic accidental load conditions shall be identified. Identified accidental loads that cannot be neglected due to low probability of the event shall be included in the design calculations.

**6.6.7** In the period from topside weight transfer to the substructure until the permanent connection between topside and substructure has been established, the topside shall be horizontally restrained.

The capacity of the horizontal restraint capability shall be sufficient to hold the topside or the deck in the worst possible damage case including wind heel and possible effects of current and waves. The effects of friction shall be taken into account.

Connections between the topside and the substructure shall have sufficient strength to withstand at any draft the loads arising at the lesser of the following inclination angles in combination with the inclination due to wind:

- angle at which flooding takes place;

- angle at which the allowable stresses are exceeded in the structure or in its parts;

- angle of 15°.

**6.6.8** The barge supports shall have sufficient strength to withstand all vertical forces and horizontal forces introduced by deflections of the topside and the barge during weight transfer.

The substructure shall be protected against possible accidental loads such as mooring line failure (not relevant if the mooring lines are slack during topside mating), flooding of buoyancy pontoons, dropped objects, collision loads.

**6.6.9** The ballast/deballast system shall:

- have sufficient capacity to complete the mating operation within the time limitations determined by the weather window. Normally, the operation shall be designed to be performed within a period of 48 hrs;

- be capable of leveling the structure by eccentric ballasting/deballasting to compensate for any shift of the centre of gravity during the mating operation;

- prevent accidental cross flooding and uncontrolled ingress of water;

- ensure reversibility of the operation, that is, restoration of the safe draft.

**6.6.10** Valves used for ballasting/deballasting shall be doubled when installed on the objects not complying with the one compartment damage stability requirement.

**6.6.11** The design shall provide for the following tank water level control systems:

- remote reading sounding system;

- a back-up system, e.g. ullaging by hand.

**6.6.12** Ballast compartments, which are intended to remain dry, shall have adequate drainage capability to eliminate uncontrolled ingress of water.

**6.6.13** Provision shall be made for monitoring and control of the ballasting/deballasting to prevent excess structural loading during ballasting and deballasting of the compartments.

**6.6.14** Umbilicals of the hydraulic systems shall be adequately protected and be backed up to cover breakdowns or rupture.

**6.6.15** Systems and arrangements shall have adequate redundancy to cover failures during the object transfer within the defined period.

**6.6.16** The design shall provide for a primary and secondary positioning systems.

The primary positioning system incorporates mooring and towing arrangements for the substructure and barge, which shall be capable of securing the structure in predetermined position in the event that the mating operation is interrupted. The primary positioning system shall ensure safe positioning of the barge close to the substructure.

The secondary positioning system shall ensure accurate and well controlled positioning of the barge with the topside located thereon above the substructure. The positioning shall take place without causing local impact loads exceeding the energy absorption capability of the positioning shock absorbers. Winches, wires, jacks of this system shall have sufficient capacity to resist wind forces, wave forces, current forces.

**6.6.17** If ships specially intended for performing mating operations by float on method, e.g. flo-flo type ships, they shall be positioned using their own anchors in the water area previously surveyed by divers.

Where a barge without regular anchor arrangement intended for its securing is used, the equipment including anchors, bridles and mooring buoys to which the barge is moored shall be installed prior to commencement of mating operation by float on method.

**6.6.18** Prior to mating operation, the following shall be tested:

- compliance of the freeboard with that determined in the design;
- availability of structures specified by the design and which shall be tested according to their specifications;
- possibility of remote control of the ballast valves and the by-pass valves fitted in the watertight bulkheads;
- adequate protection of all inlets to prevent damage by entering debris and cables;
- condition of the temporary closures;
- absence of debris in the internal compartments to be closed.

Trials shall be carried out to test the operation of the equipment and systems and watertightness of the object.

**6.6.19** During mating, the relative movements of the objects due to environmental loads shall be carefully considered. All back-up systems shall be ready for immediate activation during the critical stages of the mating operation.

**6.6.20** All connections between the barge and the object structures shall be properly removed prior to commencement of weight transfer.

**6.6.21** Assuming maximum excursions caused by environmental loads, the following minimum bottom clearances apply:

- vertical clearance of 10 m under the bottom of a substructure;

sideways clearance during positioning shall be of 0,5 m;  
vertical clearance of 0,25 m shall be maintained between the underside of the object and the top of the substructure;

if the substructure has underwater horizontal elements, a minimum barge underkeel clearance of 0,5 m shall be maintained.

**6.6.22** The following parameters shall be monitored manually or by monitoring systems during mating operations:

environmental conditions (monitoring shall begin well in advance of the operation);

relative position, orientation, and clearances of substructure and topside prior to and during positioning;

clearances between barge deck supports and topside;

trim, heel and draft of barge and substructure;

submersion/emersion rate of the barge and substructure;

barge and substructure motions parameters;

water level and air pressure (if applicable) in barge and substructure compartments;

open/closed status for ballast valves.

**6.6.23** To float the topside over the substructure use shall be made of tugs, winches or combination of these. Structures shall be joined by reference points or by optical/laser systems.

**6.6.24** During the mating operation, support reaction measurements and comparison of the results with the design ones. The actual deviation in total load and moments shall be noted for each measurement and compared with agreed tolerances.

## **6.7 Connection with other objects**

**6.7.1** Connection with the previously installed objects shall be carried out in accordance with the design requirements and applicable provisions of the MODU/FOP Rules.

**6.7.2** Where connection is made to subsea pipeline, the strength test of the spool pieces between the pipeline end manifold (PLEM) and the installed object shall be carried out during manufacture in compliance with the requirements of the Rules for the Classification and Construction of Subsea Pipelines<sup>1</sup>. After connection to the object and subsea pipeline the leak test of spool pieces shall be carried out in compliance with the requirements of the SP Rules. If connection to the subsea pipeline is carried out by welding, the strength and leak tests of spool pieces and field joints shall be carried out in compliance with the requirements of the SP Rules.

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<sup>1</sup>Hereinafter referred to as "the SP Rules".

## **7 DECOMMISSIONING AND REMOVAL**

**7.1** In order to ensure safety of navigation and fishing and also to prevent the pollution of the marine environment, the abandoned and unused structures and installations shall be removed (dismantled) by their owners within the time periods stipulated in their construction permit.

**7.2** Information on complete or partial removal (dismantling) of the structures and installations with indication of water depth, geographical coordinates and sizes of those structures and installations which have not been completely removed shall be delivered to the Head Department of Navigation and Oceanography of the Ministry of Defence of the Russian Federation and to the Federal Agency for Sea and Inland Water Transport for publication in the Notices to Mariners, sailing directions and other nautical publications.

**7.3** Prior to removal (dismantling), the production process on the object shall be completely stopped, the equipment shall be completely released from products, all the pipelines and apparatus shall be flushed out, steamed and, if necessary, shall be purged by inert gas. Measures shall be taken to prevent freezing of the liquid residues in the pipelines and apparatus. Explosive, radioactive and toxic substances shall be removed from the object, meeting all the requirements of the existing normative documents. Wells shall be abandoned or suspended in accordance with the established procedure.

**7.4** Systems essential for the safe functioning of the object shall operate under normal operational conditions until equipment dismantling.

**7.5** After removal the site shall be safely cleared of debris. The procedure of handling harmful and dangerous substances shall be defined.

**7.6** If the object or parts thereof will be reused, all the disassembly operations shall be performed in compliance with the requirements of these Rules. Calculations shall take account of changes made in operation and of the actual object condition.



## PART IV. SAFETY ASSESSMENT

### 1 GENERAL

**1.1** The marine operation design shall ensure an acceptable safety and exclude/minimize:

- fatalities or loss of health of people involved in a marine operation;
- pollution or other kinds of damage to the environment;
- losses/failures of object and technical facilities involved in performance of marine operation.

**1.2** The safety assessment shall be carried out, as a minimum, in developing designs for category 3 and 4 marine operations. It is recommended to use formal safety assessment (FSA) methodology specified in MSC/Circ.1023 and MEPC/Circ.392, as well as in Part XV "Safety Assessment" of the MODU/FOP Rules.

**1.3** The hazards revealed in the process of identification shall be correlated with the tolerable risk criteria. In this case, the tolerable risk criteria and the risk assessment results may be reflected either qualitatively (in the form of text and matrices) or quantitatively by risk index calculation.

**1.4** In order to assess the damage suffered by personnel, the following safety criteria may be accepted:  
individual risk:

- unacceptable risk level –  $10^{-3}$  fatalities per year;
- the range within  $10^{-3}$  to  $10^{-6}$  is the ALARP (as low as reasonably practicable) zone;
- tolerable risk level –  $10^{-6}$  per man per year.

societal risk ( $\geq 10$  deaths):

- risk  $> 10^{-3}$  per man per year – unacceptable risk zone;
- risk  $< 10^{-3}$  per man per year, but  $> 10^{-5}$  per man per year – tight risk control zone (intermediate risk values);
- risk  $< 10^{-5}$  per man per year – tolerable risk zone.

## RECOMMENDATIONS FOR LIFTING EQUIPMENT<sup>1</sup>

### 1 Padear

**1.1** In strength calculation, consideration shall be given to additional horizontal load equal to about 5 per cent of the sling load applied at the level of the hole for shackle pin.

**1.2** Inclination of the sling from the padear plane shall not exceed  $\pm 5^\circ$ .

**1.3** The main welds shall withstand shear forces. Elements subjected to forces perpendicular to the rolled product thickness shall be manufactured of zet-steel.

**1.4** Radius of the main padear plate shall not be less than the maximum of two values:

$$1,25 \times D;$$

$$D/2 + 75 \text{ mm}$$

where  $D$  = the diameter of a hole for the shackle pin.

**1.5** The diameter of a pinhole shall be, as maximum, 5 mm greater than the hole diameter of the rigging shackles with  $SWL > 200 \text{ t}$ , and 3 mm greater at  $SWL < 200 \text{ t}$ .

**1.6** Pinholes shall be machined, and boring shall follow welding of the doubling plates to base plates.

**1.7** All acute angles that can damage sling during loading and transportation shall be rounded off.

**1.8** Doubling plates.

**1.8.1** If doubling plates are used, they shall be fitted on both sides of the base plate.

**1.8.2** The thickness of a doubling plate shall be less than or equal to the thickness of the base plate.

**1.8.3** The doubling plate shall be round, with the greatest allowable diameter. Radius of the doubling plate shall be equal to the radius of the base plate minus the thickness of the doubling plate.

**1.8.4** The doubling plate shall be welded all round to the base plate by fillet welds, as well as by intermittent welds inside the pinhole, if the hole diameter exceeds 100 mm.

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<sup>1</sup>Where no other methodologies are available, the calculations according to this Appendix may be adopted.

Upon agreement with the Register the calculations according to ISO 19901-6 "Petroleum and Gas Industries – Specific Requirements for Offshore Structures. Part 6: Marine Operations" may be used.

The fillet weld root shall be located at a distance of at least 5 mm from the base plate edge.

Welds in the hole shall not be taken into consideration in the calculations.

**1.8.5** Centralizers shall be used to reduce clearances between the padear and the rigging shackle to 5 mm on both sides. Centring rings shall not be welded to the doubling plate.

## **2 Trunnions**

**2.1** The trunnion diameter shall be, as a minimum, 4 times greater than the sling diameter.

**2.2** The trunnion width shall be, as a minimum, 1,25 times greater than the sling diameter plus 25 mm.

**2.3** The trunnion shall be provided with a device to prevent the sling from slipping.

## **3 Cast padears**

**3.1** Strength shall be analyzed and verified by calculation.

**3.2** Finished castings shall be subject to a stringent quality control, including dimensional inspection, determination of chemical composition and mechanical properties of material and non-destructive testing.

## **4 Platform for rigging**

Platform for rigging shall meet the following requirements:

be provided with handrails around the platform;

withstand rigging weight (slings, shackles, spreader bars, etc.) plus uniformly distributed load of 5 kN/m<sup>2</sup>.

## **5 Fenders and guides**

**5.1** The fenders and guides shall:

facilitate positioning of the object after lifting within the required tolerances;

protect the object being lifted, adjacent structures and equipment against damage during lifting.

**5.2** The specific requirements for the fenders and guides shall be specified as early as at the planning stage considering lifting technique and damage risk assessment.

**5.3** Manufacturing tolerances shall be closely checked. Prior to lifting, the obtained dimensions of the guides shall be checked to verify maintenance of operational tolerances.

**5.4** The design loads on the fenders and guides shall not be less than those given in Table 1.

**5.5** The fenders and guides shall be calculated for any combination of forces.

**5.6** The requirements for the design impact loads on the guides are given in Table 2.

Table 1

Design loads acting on the structures			
Force	Fenders (Bumpers)	Guides	Pin/piston
Vertically directed friction force	1 % MDW	1 % MDW	1 % MDW
Vertically directed stabbing force ( $F_v$ ) (type of rising pier)	10 % MDW	10 % MDW <sup>1</sup> 20 % MDW <sup>2</sup>	10 % MDW
Horizontally directed friction force	1 % MDW	1 % MDW	1 % MDW
Horizontal force directed normally in the plane of bumper ( $F_h$ )	10 % MDW	5 % MDW	5 % MDW
Horizontally directed force in any direction ( $F_i$ )	5 % MDW	5 % MDW	5 % MDW
<sup>1</sup> For secondary structures. <sup>2</sup> For primary structures. Note. Different fender (bumper) and guide configurations are shown in Figs. 1; 2.			

Table 2

Design impact loads acting on the structures		
Force	Primary structure	Secondary structure
Vertically directed stabbing force	10 % SHL	5 % SHL
Horizontally directed stabbing force in longitudinal direction	10 % SHL	5 % SHL
Horizontally directed stabbing force in transverse direction	10 % SHL	5 % SHL
Note. Different fender (bumper) and guide configurations are shown in Figs. 1; 2.		

## 6 Guiding system

**6.1** When designing the guiding system (bumpers, guides, lugs, pins and buckets), the following requirements shall be taken into account:

position of each element of the guiding system shall depend on the acceptable support points on the object;

residual deformations of any part of the object shall be prevented;

connections of bumpers and guides, and the members supporting bumper or guide locations, shall be at least as strong as the bumpers and guides;

stiffness of bumper and guide members shall be as low as possible, in order that they can deflect appropriately without yielding;

easy sliding motion of the bumper when in connection with the guide shall be ensured;

sloping member of guides shall be at an acute angle to the direction of movement;

ledges and sharp corners shall be avoided in areas of possible contact;

weld beads shall be ground flush.

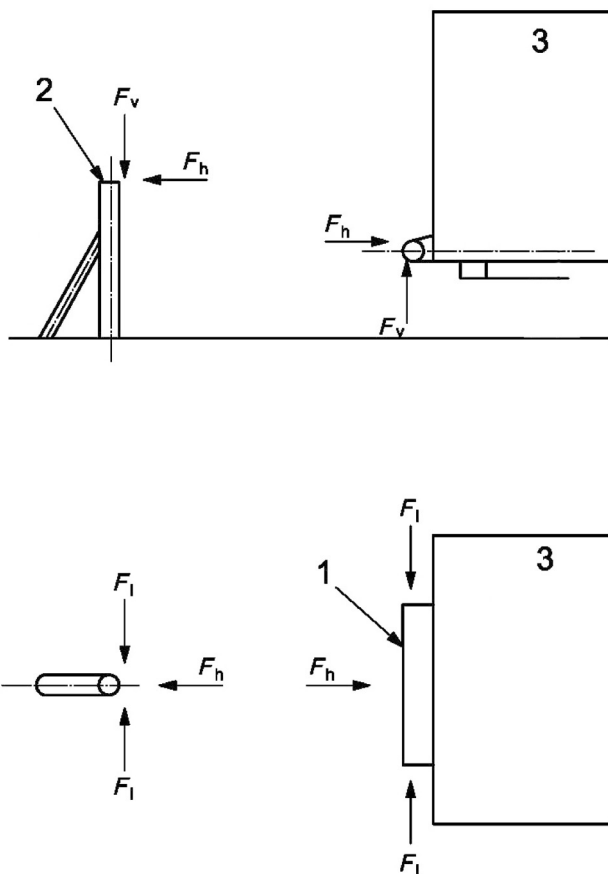


Fig. 1  
Fender (bumper) and guide configurations:  
1 – horizontal primary bumper  
2 – primary guide  
3 – incoming module

**6.2** For bumpers and guides designed as secondary structures, the forces  $F_v$ ,  $F_h$  and  $F_l$  may be taken equal to 50 per cent of the values given in Table 2.

**6.3** The bumpers with vertical guide shall be designed for the following loads:  
horizontally directed force in any direction ( $F_h$ ):  $0,10 \times W$   
where  $W$  is equal to the sum of the gross weight and the rigging weight, in t;  
vertically directed (friction) force ( $F_v$ ):  $0,01 \times W$ .

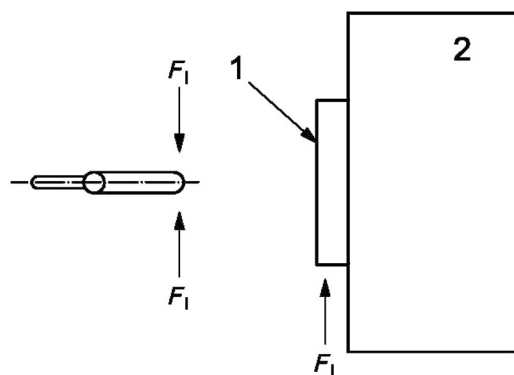
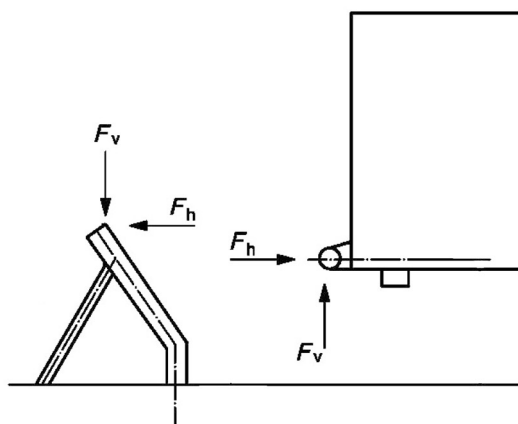


Fig. 2

Bumper and guide configuration

1 – horizontal primary bumper

2 – incoming module

The vertical guide with horizontal bumper:

horizontally directed force in any other direction ( $F_h$ ):  $0,05 \times W$ ;

vertically directed (stabbing) force on inclined face of guide ( $F_v$ ):  $0,10 \times W$ .

The loads in all relevant directions shall be combined to establish the most onerous loading condition.

## **7 Slings**

**7.1** For doubled slings due attention shall be paid to friction losses in way of the cargo handling gear or crane hook, the total sling force shall be divided between two sling parts in the ratio of 45 to 55.

**7.2** Where possible, slings shall be pre-installed on the object to simplify lifting and access to the eyes and lifting points, as well as to remove safely the slings and shackles.

**7.3** Minimum distance from the sling to any obstacles shall be 3 m.

**7.4** Minimum tilt angle of the sling shall be  $60^{\circ} \pm 5^{\circ}$ .

**7.5** Breaking strength of the sling bent around a trunnion shall be multiplied by the bending coefficient  $C_{bend}$  equal to:

$$C_{bend} = 1 - 0,5 \times (d_2/d_1)^{1/2}$$

where  $d_1$  = trunnion diameter;  
 $d_2$  = sling diameter.

**7.6** The length of slings shall be within  $\pm 0,25$  per cent of their nominal length. During measuring, the slings shall fully tensioned and adequately stressed under the action of a load which shall be in the range of 2,5 to 5,0 per cent of MBL (minimum breaking load).

**7.7** Used slings shall be inspected by a competent expert before each lift. If a sling is not a loose gear of the ship's cargo handling gear covered by periodical surveys, examinations and tests, the detailed background records of the sling and records of lifts for which the slings have been used shall be available for inspection.

## **8 Hydraulic clamps**

**8.1** Hydraulic clamps are recommended to be used for lifting and upending of piles.

**8.2** Clamps shall be so designed that failure to hydraulic systems during lifting does not result in cargo falling.

**8.3** Forces from the clamps shall be transferred to the lifting points in accordance with the requirements of these Rules.

**RECOMMENDATIONS FOR CALCULATIONS AND MODEL TESTS  
OF THE OBJECT LAUNCHING, TILTING, FLOATATION  
AND SETTING DOWN ON THE SEABED**

**1 Launching of the object from barge**

**1.1 General**

**1.1.1** The objective of launching investigation is to analyze behavior of the object and barge at various launching stages. This investigation shall consider an accident situation including filling of the ballast tank.

**1.1.2** Below are given the minimum requirements for launching investigation. Depending on the size and weight of the object to be launched, more detailed investigations may be required.

**1.1.3** Launching investigation at the stages from commencement of movement till stable position in water includes the following calculations:

hydrodynamic calculation which shall determine displacement and resultant load acting on the object and barge;

structural calculation which shall determine stresses arising in the object and barge structure.

**1.1.4** Launching investigation shall identify requirements for buoyancy pontoons.

**1.2 Hydrodynamic analysis of launching**

**1.2.1** This analysis shall be made using a recognized computer program which shall be certified and shall describe in detail the following:

systems of coordinates;

initial data;

output data.

**1.2.2** Models used for the barge, object, launching ways and rocker arm, as well as the main hypothesis shall be documented in detail in the explanatory note which shall at least include the following:

geometry;

mass and moments of inertia;

hydrodynamic factors;

ballast tanks and other displacing volumes including arrangement of buoyancy pontoons;

boundary conditions (sliding cradle friction coefficient);

initial conditions for launching (angle of trim, barge draft, position of the object on the barge);



water depth;

calculation tact (not more than 2 s) and number of tacts under investigation;  
accident situation (flooding of one ballast tank that provides the worst result).  
Relevant drawings shall be included into explanatory note.

**1.2.3** The following results shall be documented in detail in the explanatory note for each calculation tact in the form of object-barge function;

object position relative to the barge (CoG position about the rocker arm axis);

object position relative to the water surface and the seabed;

vertical and horizontal velocities of the CoG of the object and barge;

rocker arm reactions;

forces and moments of buoyancy of the object;

sum of the acting forces and moments;

stability criteria (CoB position, metacentric height in two directions and righting moment);

waterline parameters (moments of inertia, angle between the main axis and the system of coordinates, CoG position);

**1.2.4** The following characteristics of the trajectory shall be documented and accompanied by figures (one per calculation tact):

barge trim (forward and aft drafts);

CoG position of the object;

rocker arm bending;

depth of the highest point of the object in water;

depth of the lowest point of the object in water;

horizontal and vertical velocities of the object centre of gravity;

horizontal velocity of the barge centre of gravity;

equilibrium position of the object;

time from the moment of operation commencement.

**1.2.5** The following acceptance criteria shall be provided:

depth of the highest protruding member of the object shall not exceed 30 per cent of the water depth;

position of the lowest protruding member of the object above the seabed shall not be less than 10 m in intact condition and 5 m when one ballast tank is flooded;

object speed relative to the barge shall not exceed 1 m/s.

### **1.3 Structural analysis of launching**

**1.3.1** The behaviour of the object structures during launching shall be verified by a static analysis based on the loads obtained according to 1.2.

**1.3.2** Each position of the object shall be analyzed in passing the rigid points of the rocker arm considering transverse loads equal to 0,05 MDW which acts on the sloping surface.

**1.3.3** The stresses involved shall be compared with the allowable stresses.

**1.3.4** Launching tools/appliances (pushing or pulling lugs, sideways guides, etc.) shall be calculated taking into account uneven load distribution in the ratio of 25 per cent to 75 per cent.

The pushing or pulling lug shall be designed for the action of maximum power produced by the pushing /pulling equipment when the coefficient of static friction is increased by 1,5 times.

**1.3.5** The structural integrity of ballast tanks, waterproof membranes, etc. under the action of hydrostatic pressure, impact loads, etc. shall be confirmed.

**1.3.6** Loads and stresses arising in the barge structure including rocker arms shall be within the allowable ones.

## **2 Flotation of an object**

**2.1** Investigations of the object behaviour while in self-floating condition shall be carried out regardless of the installation method.

**2.2** The following results shall be included in the calculation for an intact object and for the case with a ballast tank flooded:

position of the center of buoyancy;

righting moments for various inclinations up to 6°;

heeling moment necessary to change the object draft by 0,5 m;

metacentric height in two directions;

waterline parameters.

**2.3** The possibility of meeting the following requirements shall be confirmed: in shallow waters and in critical situations, the reserve buoyancy shall be 20 per cent in intact condition and 12 per cent when one tank is flooded. For other cases these values may be reduced to 15 per cent and 8 per cent, respectively;

righting moment shall be positive for an inclination up to  $\pm 6^\circ$ ;

heeling moment necessary to change the object draft by 0,5 m shall be less than the relevant righting moment;

metacentric height shall be positive at all times and more than 1 m.

## **3 Upending of the object by means of a crane**

**3.1** The objective of the investigations is to analyze the object behaviour, determine the hook loads and develop the ballasting plan during the upending of horizontally floating object to the vertical position. This objective shall be achieved through performance of a three-dimensional hydrodynamic analysis which considers at least 10 intermediate steps.

**3.2** The hydrodynamic analysis shall be made using a program meeting the requirements of 1.2.1.

**3.3** The following results in the form of tables and curves of relative object position for each intermediate step, which define the equilibrium position shall be presented:

ballasting scheme;  
change in ballasting scheme as compared to preceding step;  
hook and sling load;  
angles of roll and pitch;  
bottom clearance;  
metacentric height about both axes;  
positions of centres of gravity and buoyancy;  
position of the object relative to water.

**3.4** The following acceptance criteria shall be met:

metacentric height shall be positive and more than 1 m;

bottom clearance shall not be less than 5 m;

allowable hook loads:

if the object weight (in air) is less than or equal to the crane capacity, the allowable hook load shall be taken equal to the crane capacity;

if the object weight (in air) is by 1 to 1,5 times greater than the crane capacity, the allowable hook load shall be taken equal to 2/3 of the crane capacity;

if the object weight (in air) is more than by 1,5 times greater than the crane capacity, the allowable hook load shall be taken equal to 1/3 of the crane capacity.

**3.5** Structural inspection.

**3.5.1** The object structure shall be verified considering the hook loads obtained as a result of the hydrodynamic analysis.

**3.5.2** The object parts and buoyancy pontoons shall be checked for strength under the action of hydrostatic pressure.

**3.5.3** In the lift points, consideration shall be given to the change of sling angle during tilting due to application of an additional transverse force comprising 10 per cent of the load on the slings.

#### **4 Upending of the object by means of ballasting**

**4.1** The objective of the investigation is to analyze the object behaviour, develop the ballasting plan during upending of horizontally floating object to the vertical position. This objective shall be achieved through performance of a three-dimensional hydrodynamic analysis which considers, at least, one step for each inclination to 10°.

**4.2** The stability and position of the object shall be verified according to the requirements of Section 3.

**4.3** The metacentric height shall be greater than any of the following values:

0,2 m;

$0,002 \times$  height of the object in inclined position;

$0,01 \times$  height of the object in vertical position.

**4.4** The bottom clearance shall be more than 5 m.

**4.5** The object parts and buoyancy pontoons shall be checked for strength under the action of hydrostatic pressure.

**5 Setting down the object on the seabed**

**5.1** The objective of the investigation is to analyze the object behaviour during setting down on the seabed and the step-by-step inspection (step down – 1 m).

**5.2** Calculation shall be made according to the requirements of Section 3.

## RECOMMENDATIONS FOR SOLID BALLAST PLACEMENT

### 1 General

**1.1** Solid ballast in the form of high flowability concrete to be loaded on the object may be of two types:

mass type with bulk density of 2200 to 2500 kg/m<sup>3</sup>, may be lightened with the crushed stone being replaced by sand and with bulk density of 1850 kg/m<sup>3</sup> (type I);

structural type, that is bearing external load, e.g. ice load with bulk density of 2250 to 2400 kg/m<sup>3</sup> (type II).

**1.2** Depending on the peculiarities of design, construction, transportation, operation and dismantling/removal, concrete may be placed at various places:

at the yard water area;

at relatively sheltered water area (in bay, gulf, etc.);

on-site (in a floating/fixed condition).

In the two last cases, the concrete may be placed from a suspended platform, moored pontoon, supply vessel or from the deck of the object with the topside installed.

**1.3** Regardless of the point of placement, the concrete shall withstand alternate freezing and thawing, as well as temperature gradient which cause thermal crack formation in the concrete.

In cold season, the concrete can be cooled to -55 °C on the shell plating in the above-water part and simultaneously, when in contact with oil, heated up to + 60 °C on the inner skin.

It may be practicable to use various concrete types depending on the operational conditions and arrangement of filled spaces.

**1.4** The major factors which determine concrete quality are as follows:

use of base materials which are the most durable under operational conditions;

design and selection of the concrete optimum composition at low-water discharge;

application of concrete making and consolidation technique contributing to the production of the most homogeneous structure of the cement stone and concrete texture;

creation of the appropriate thermal and moisture conditions of the concrete curing which determine production of a durable structure of the cement stone and reduce thermal stresses in the concrete.

**1.5** The recommended technical characteristics of aggregates, concrete mix and concrete are given in Table 1.

**1.6** To improve the basic properties of the concrete, reduce water consumption, provide easy concrete placement and reduction of cement consumption, it is recommended to add air-entraining admixtures and plasticizers to concrete mix in compliance with the normative-technical documentation.

Application of power station fly ash as an active mineral admixture is permitted.

## **2 Process requirements**

**2.1** List of applicable standards and specifications is given in Table 2.

**2.2** The performer shall carry out cement, coarse aggregate and sand quality control.

**2.3** The concrete mix shall be made by a forced-type concrete mixing plant, for the type II concrete a gravity-type mixer may be used.

**2.4** When organizing work and selecting technology, the ambient temperature shall be taken into consideration.

**2.5** The concrete mix delivery pipeline shall be made of steel seamless pipes connected together by lever locks and flexible inserts. It is reasonable to mount the concrete mix delivery pipelines, two working and one stand-by main, during construction of the object.

**2.6** To ensure loading of the upper part of the compartments, it is recommended to provide special access holes with dimensions of 400 x 300 mm in each compartment cell.

**2.7** To place the concrete mix directly into the compartment cells it is recommended to use steel pipes (trunks), two pipes per cell. To reduce pressure in the trunk during delivery of the concrete mix special holes shall be provided at the end portion. Upon completion of delivery of the concrete into the cell, the trunk shall remain inside.

Table 1

## Technical characteristic of the concrete

Characteristic	Concrete type	
	I	II
<b>Requirements for the concrete mix components</b>		
<i>Cement</i>		
Concrete grade	400	400
Consumption per 1 m <sup>3</sup> of concrete, in kg	440 — 460	460 — 480
<i>Coarse aggregate</i>		
Fractional composition, in mm (%)	10 — 20 (35 — 60) 20 — 40 (65 — 40)	5 — 10 (25 — 40) 10 — 20 (75 — 60)
Strength, in kg/cm <sup>2</sup>	800	1000
Consumption per 1 m <sup>3</sup> of concrete, in kg	1100 — 1200	1050 — 1150
Sand, consumption per 1 m <sup>3</sup> of concrete, in kg	680 — 730	700 — 750
Water, consumption per 1 m <sup>3</sup> of concrete, in l	150 — 160	160 — 170
<i>Requirements for the concrete mix</i>		
Slump (fluidity), in cm	12 — 16	12 — 16
Maximum water – cement ratio	—	0,4
Entrained air content, in %	2 — 3	2 — 3
Water separation, in %	—	< 2
<i>Requirements for the concrete</i>		
Minimum compressive strength of a standard specimen (15 × 15 × 15 cm), in MPa	30	42
Maximum compressive strength of a standard specimen (15 × 15 × 15 cm), in MPa	—	54
Maximum period of concrete specimen curing by the time of compressive strength test, in days	90	28
Density:		
minimum, in kg/m <sup>3</sup>	2400	2250
maximum, in kg/m <sup>3</sup>	2500	2450
Maximum temperature difference between the interior of the concrete block and the surface thereof, in °C	25	—

Table 2

**List of standards and specifications applicable to solid ballast placement**

Designation	Code name
Cements. Test methods. General	GOST 310.1-76
Cements. Methods of grinding fineness determination	GOST 310.2-76*
Cements. Methods of tests of consistency, times of setting and soundness	GOST 310.3-76*
Cements. Methods of tests of bending and compression strengths	GOST 310.4-81*
Ready-mixed concrete. Specifications	GOST 7473-94
Crushed stone and gravel of solid rocks for construction work. Specifications, amend. No 3, 1995	GOST 8267.0-93*
Maintainous rock road-metal and gravel, industrial waste products for construction work. Methods of physical and mechanical tests	GOST 8269.0-97*
Maintainous rock road-metal and gravel, industrial waste products for construction work. Methods of chemical analysis	GOST 8269.1-97
Sand for construction work. Testing methods	GOST 8735-88*
Sand for construction works. Specifications	GOST 8736-93*
Concretes. Methods for strength determination using reference specimens	GOST 10180-90
Concrete mixtures. Methods of testing	GOST 10181-2000
Concretes. Rules for the strength control	GOST 18105-86*
Sulphate-resistant cements. Specifications	GOST 22266-94
Water for concretes and mortars. Specifications	GOST 23732-79
Additives for concretes and mortars. General specifications	GOST 24211-2003
Heavy-weight and sand concretes. Specifications	GOST 26633-91*
Concretes. Rules for mix proportioning	GOST 27006-86
Concretes. Methods of strength evaluation on cores drilled from structures	GOST 28570-90
Cements. General specifications	GOST 30515-97
Phenya ethoxysilosaene 1113-6-3	TU 6-02-995
Wood tar, saponified	TU 13-05-02
Super plasticizer S-3 (dilutant)	TU-36-0204229-625
* Valid GOST as amended	



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