RUSSIAN MARITIME REGISTER OF SHIPPING

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# RULES

## FOR THE CLASSIFICATION AND CONSTRUCTION OF UNMANNED UNDERWATER VEHICLES

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# RULES FOR THE CLASSIFICATION AND CONSTRUCTION OF UNMANNED UNDERWATER VEHICLES

Rules for the Classification and Construction of Unmanned Underwater Vehicles have been approved in accordance with the established approval procedure and come into force on 1 January 2023.

The Rules are published in electronic format in Russian and English.

**REVISION HISTORY**

(purely editorial amendments are not included in the Revision History)

For this version, there are no amendments to be included in the Revision History.

# GENERAL REGULATIONS

## 1 SCOPE OF APPLICATION

**1.1** Russian Maritime Register of Shipping (RS, the Register) as the body of technical supervision and classification of ships establishes the technical requirements ensuring conditions of safe navigation of unmanned underwater vehicles (UUV). The Rules for the Classification and Construction of Unmanned Underwater Vehicles are applied by the Register for carrying out the technical supervision and classification of UUV of 10 kg in mass and above. For UUV in service having the specified characteristics, these Rules may be applied to the extent possible and reasonable.

**1.2** The unmanned underwater vehicles are to the full extent covered by the Rules for the Prevention of Pollution from Ships intended for Operation in Sea Areas and Inland Waterways of the Russian Federation. The Rules for the Classification and Construction of Sea-Going Ships and the Rules for the Equipment of Sea-Going Ships are applied to the extent specified in the respective parts of these Rules.

**1.3** During technical supervision of unmanned underwater vehicles, in addition to the above-mentioned Rules, also the Rules for the Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships, the Rules for the Classification Surveys of Ships in Service and respective provisions of the Guidelines on Technical Supervision of Ships under Construction and Guidelines on Technical Supervision of Ships in Service are applied.

**1.4** These Rules establish the requirements, compliance with which will allow UUV to be classed by the Register.

**1.5** Technical supervision of the Register does not substitute the activity of the technical supervisory bodies of the shipowners, shipyards and manufacturers.

## 2 TERMS AND DEFINITIONS

For the purpose of these Rules, the following definitions and explanations have been adopted, unless expressly provided otherwise in particular parts.

Autonomous Underwater Vehicle (AUV) means an unmanned underwater vehicle capable of moving, submerging and emerging autonomously according to the preset sequence or commands via telemetry.

Buoyancy materials means materials for UUV buoyancy blocks the density of which is lower than the density of its operation environment.

Buoyancy volume of UUV means the volume of water displaced by all the watertight structures of the unmanned underwater vehicle.

Carrier ship of UUV means a ship or floating facility intended for accommodation and delivery of UUV to the area of diving operations, for support of UUV diving, as well as for in-service UUV maintenance.

Communication tether cable means a connection between the carrier ship and ROV that may include cables of monitoring, control, power supply and data exchange lines as well as a lifting cable.

Competent authorities mean organizations supervising construction and operation of UUV as for issues not regulated by the RS rules.

Design pressure means a maximum pressure (external or internal) for which UUV hulls or their structural members are designed.

Endurance (of UUV) means the maximum time of UUV operation from its own power source in the operation environment.

Energy supply system means a set of equipment combined by design for power supply of equipment and systems of the UUV. The energy supply system contains individual power sources (main, emergency and stand-by ones) and energy distribution systems.

Handling system means a combination of equipment, machinery, systems and arrangements intended for lowering and lifting the unmanned underwater vehicle from the carrier ship (floating facility) to/from water.

Lifting mass of UUV means the mass of UUV recovered from water with due regard to the instantaneous values of the masses of water remaining in non-watertight parts.

Mass of UUV means the total mass of UUV with outfit and equipment.

Operating diving depth of UUV means the maximum depth, to which UUV can dive the secured number of times and remain there during the specified period of time.

Operating pressure means the maximum pressure of air or gas medium which can be built up in UUV for the secured number of times and maintained during the specified period of time.

Operator means a person(s) having relevant qualification and appointed to control the ROV.

Pressure-resistant structures mean pressure hulls, pressure tanks, pressure vessels and other elements as a part of UUV which directly take up and balance the operational loads resulted from overpressure of water or gas medium.

Propulsion and steering complex means a set of machinery combined by design for UUV movement and space manoeuvring.

Remote control console means a set of controls located on a single common panel (structure) sufficient for remote control of the UUV.

Remote control station means a place equipped with controls from which the operator can carry out remote control.

Remote control system means a set of technical means for control of the unmanned underwater vehicles, remote control console or remote control station.

Remotely operated vehicle (ROV) means a UUV connected to a carrier (ship, submarine, underwater vehicle) by the communication tether cable which is used for transmission of power and/or control signals as well as for information exchange.

Reserve of UUV buoyancy means the buoyancy corresponding to the watertight volume above the effective waterline of the unmanned underwater vehicle when afloat (it is expressed in per cent as the ratio of the ballast tanks volume to the buoyancy volume of UUV).

Strength tests mean testing of pressure-resistant structures of UUV and other pressure vessels as a part of UUV for strength as an assembly by applying test pressure (pressure equal to test diving depth or test gas medium pressure) as agreed upon with the Register by one of the following methods:

with external pressure in a test chamber;

by submersion into the sea;

with internal hydraulic pressure.

Test diving depth means a depth to which UUV dives during tests after construction, repair or modification, as well as during in-service surveys.

Test pressure in strength tests means an internal pressure which exceeds the operating pressure and created during strength tests of compartments and other pressure vessels as a part of the unmanned underwater vehicle.

Tether management system (TMS) means an underwater device designed to house a winch with ROV cable, and used to grip the ROV, launch and recover it as well as to avoid influence from load-carrying communication tether cable on ROV in the water column.

Tightness tests mean testing of welds and structure of hulls as a whole, bulkheads, hatches, covers, viewports, piping connections, valves and pressure vessels, using methods approved by the Register, under the following conditions:

with internal working gas medium pressure equal to the operating pressure – for UUV compartments and other UUV vessels operating under internal overpressure;

with internal air pressure specified by the designer and agreed with the Register – for UUV compartments and tanks operating under higher hydrostatic pressure;

with internal working medium pressure equal to the operating pressure, no matter what the pressure (internal or external) they work under on UUV – for pipe to fitting connections. Tightness tests for the unmanned underwater vehicles may be performed by an external hydrostatic pressure.

Umbilical is an external communication line of ROV that includes cables of monitoring, control, power supply and data exchange lines.

Underwater vehicle (UV) means a technical unit capable of running submerged and/or moving on the seabed and designed for different underwater tasks and observations.

Unmanned underwater vehicle (UUV) means an underwater vehicle remotely operated via the communication tether cable by the operator located on the carrier or on shore (ROV) or operating autonomously according to the program (AUV).

UUV accident means an incident during navigation of an unmanned underwater vehicle resulting in the failure or loss of at least one of the seaworthiness properties preventing the performance of the assigned task and requiring restoration repair to mitigate the accident consequences.

UUV displacement means an amount of water corresponding to the buoyancy volume of UUV.

## 3 DEVIATIONS FROM THE RULES

**3.1** The Register may allow using materials, products and UUV structures or individual devices thereof other than those required by the RS rules, provided an equivalent level of safety established by the RS classification requirements is ensured. In such cases, data shall be submitted to the Register enabling to ascertain compliance of the materials, structures and products in question with the requirements ensuring the UUV safety and ecological safety of the environment.

**3.2** Where the structure of UUV, individual pieces of machinery, devices, equipment and outfit or the materials used cannot be recognized as being adequately verified in service, the Register may require special tests to be held during construction and, in case of UUV in service, may reduce intervals between periodical surveys or extend the scope of these surveys. When deemed necessary by the Register, appropriate restrictive entries may be made in the classification or other documents issued by the Register. The restrictions are withdrawn subsequent to satisfactory results obtained in service.

## 4 DOCUMENTS

**4.1** Based on the results of technical supervision and classification of UUV the Register issues documents in compliance with the applicable provisions of 1.4 of the General Regulations for the Classification and Other Activities.

# PART I. CLASSIFICATION

## 1 APPLICATION

**1.1** The requirements of this Part of the Rules cover all types of UUVs of 10 kg in mass and above designed for performing or ensuring different underwater works and observations.

## 2 CLASS OF AN UNMANNED UNDERWATER VEHICLE

**2.1** The unmanned underwater vehicle complying fully or to a degree considered adequate by the Register with the requirements of the RS rules is assigned the RS class with the class notation as specified below. The class notation assigned by the Register to UUV consists of the character of classification, distinguishing marks and descriptive notations defining structure and purpose of UUV. The character of classification, distinguishing marks and descriptive notations stipulate requirements for the following: availability of main functions and safety of UUV, structural strength and integrity of essential parts of UUV hull, safety of machinery installations, systems, mechanisms and equipment supporting non-main functions that constitute possible hazards. Distinguishing marks include requirements to safety levels and availability of equipment beyond those of the character of classification and descriptive notations. The sequence of distinguishing marks and descriptive notations being added in the class notation of a ship is set down by the provisions of this Chapter.

**2.2** The character of classification assigned by the Register to UUV consists of distinguishing marks:

**КМ⍟**, **КМ★**, **(КМ)★** — class notation for self-propelled UUVs, autonomous and tethered ones, having own means of movement in water;

**К⍟**, **К★**, **(К)★** — class notation for launched and towed UUVs having no own means of movement in water;

Depending on the Rules on the basis of which an unmanned underwater vehicle was surveyed, and the classification society which carried out the survey, the character of classification is established as follows:

**.1** UUVs built according to the RS rules and surveyed by the Register are assigned a class notation with the character of classification: **КМ⍟** or **К⍟**;

**.2** UUVs built according to the rules of ACS — IACS member and surveyed by that society during their construction and classed by the same or different ACS — IACS member during their service, when classed by the Register are assigned a class notation with the character of classification: **КМ★** or **К★**;

**.3** UUVs which were as a whole (or their hull or machinery installation, or machinery, or equipment) manufactured without being surveyed by ACS — IACS member or without being surveyed by any classification society and which were not classed by ACS — IACS member during their service, when classed by the Register, are assigned a class notation with the character of classification: **(КМ)★** or **(К)★**.

**2.3 Distinguishing marks in the class notation.**

**.1** Notations of autonomy:

**AUV** — autonomous underwater vehicle;

**ROV** — remotely operated vehicle.

**.2** Maximum operating depth.

**(…)** — notation of autonomy is followed by the maximum operating depth specified during classification trials of UUV, in m.

**.3** Mass of UUV:

**Super Lightweight** — with mass of 10 to 30 kg;

**Light** — with mass of 30 to 300 kg;

**Middle** — with mass of 300 to 5000 kg;

**Heavy** — with mass over 5000 kg.

**2.4** The sequence of the distinguishing marks in the class notation shall be the same.

**2.5** The Register may delete or alter any mark in the class notation in the case of any alteration of, or non-compliance with the requirements defining the insertion of this mark in the class notation.

# 3 TECHNICAL DOCUMENTATION OF UUV

## 3.1 GENERAL

**3.1.1** General provisions pertinent to the review and approval (agreement) of technical documentation on UUV, materials and products are given in Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

**3.1.2** Prior to the construction of a ship, technical design documentation proving that the RS requirements applicable to the unmanned underwater vehicle are complied with, shall be submitted to the Register for review. The documents submitted for review shall be forwarded to the Register by a mutually agreed method in electronic format as PDF files allowing autonomous unlimited storage and stamping with the review results.

Technical documentation shall be submitted in a scope of the plan approval documentation as listed in 3.2, taking into account the peculiarities and type of UUV without further approval of detailed design documentation for UUV under construction.

**3.1.3** Documentation, containing the results of calculations, performed using software, shall contain the reference to the name and version of such software.

**3.1.4** When the earlier approved documentation is used for construction of a similar UUV according to a new contract for construction, the scope of documentation to be submitted may be reduced based on the designer analysis of compliance with the requirements of the RS normative documents that came into force after the date of signing of the previous contract for construction for which the documentation was approved.

**3.1.5** Documentation marked with (*) is the documentation, which review results are documented by stamping in accordance with 8.3.1, Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

Documentation marked with (**) is the documentation, which review results are documented by stamping in accordance with 8.3.2, Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

Documentation marked with (***) is the documentation, which review results are documented by stamping in accordance with 8.3.4, Part II "Technical Documentation" of the Rules for Technical Supervision during Construction of Ships and Manufacture of Materials and Products for Ships.

## 3.2 PLAN APPROVAL DOCUMENTATION OF UUV UNDER CONSTRUCTION

**3.2.1 General:**

**.1** UUV specification (**);

**.2** general arrangement plans of UUV (*);

**.3** drawings showing UUV location on the carrier ship (if works are required) (*);

**.4** requirements for UUV carrier ship (if works are required) (**);

**.5** list of the main associated equipment and materials with indication of the basic particulars, firm (manufacturer) and availability of the Register approval (**);

**.6** documentation that confirms the test operation results of specific materials and products not previously approved by the Register (*);

**.7** UUV operational documentation, organizational documentation, etc. (*).

**3.2.2 Documentation on hull structures:**

**.1** structural drawings (longitudinal and transverse sections) of the UUV pressure hull (*);

**.2** drawings of UUV supports and/or suspensions (*);

**.3** description of the main production process for manufacture of UUV hulls, scope and methods of non-destructive testing (*);

**3.2.3 Documentation on equipment, arrangements and outfit:**

**.1** arrangement plan of openings in the hull with indication of the type of closing devices (*);

**.2** general arrangement plans of emergency release devices for jettisonable ballast and other equipment external to the hull; devices for emergency release of the carrying communication tether cable or umbilical; signal and emergency signal means; emergency quick-release gear (*);

**.3** general arrangement plan of UUV lifting lugs (*);

**.4** calculations of emergency devices and means referred to in 3.2.3.2 (*);

**.5** calculations of UUV lifting lugs (*);

.**6** drawings of parts and assemblies, provided they are not manufactured according to the standards or specifications approved by the Register (*).

**3.2.4 Documentation on buoyancy and stability of UUV:**

**.1** lines drawing (**);

**.2** arrangement plan of buoyancy units (**).

**3.2.5 Documentation on systems and piping**:

**.1** hydraulic diagram (**);

**.2** testing programs and methods (*);

**.3** operational documents.

**3.2.6 Documentation on UUV machinery, devices and systems:**

**.1** list of equipment and materials as well as layouts of machinery, devices and equipment (*);

**.2** description with basic details and specifications for propulsion plant components (*);

**.3** general views with sections of the propelling units (*);

**.4** diagrams and drawings of hydraulic system (*);

**.5** diagrams and drawings of submergence and surfacing systems (*);

**.6** diagrams of systems and technical documentation for their technical means and devices (compressors, pressure vessels, pumps, valves, instrumentation, etc.) (*);

**.7** testing programs and methods (*);

**.8** operational documents.

**3.2.7 Documentation on energy supply system:**

**.1** circuit diagrams of power distribution from the main and emergency sources of electrical power: power networks and lighting system (*);

**.2** calculation results of the required output of electrical power sources for all UUV operating conditions, substantiation of choice of the number and output of electric power emergency sources, as well as power calculation thereof (**);

**.3** circuit or detailed diagrams of the main current, control, monitoring (*);

**.4** general arrangement plans of electrical equipment (*);

**.5** circuit diagrams of electric drives of machinery used in submergence and surfacing systems (*);

**.6** list of electrical equipment items to be installed on UUV with indication of their technical characteristics and particulars of approval thereof by the Register or another competent body (*);

**.7** testing programs and methods (*);

**3.2.8 Documentation on radio and sonar equipment:**

**.1** electric circuit diagrams with indication of power sources if the Register does not approve the above equipment (*);

**.2** arrangement plans of the equipment (*);

**.3** arrangement plans of main and emergency power sources (*);

**.4** arrangement plans of aerials (*);

**.5** installation instructions (*);

**.6** technical description (**);

**.7** operation manual (***).

**3.2.9 Documentation on navigational equipment:**

**.1** electric circuit diagrams with indication of power sources (*);

**.2** arrangement plans of the equipment (*);

**.3** arrangement plans of main and emergency power sources (*);

**.4** arrangement plans of aerials (*).

**.5** installation instructions (*).

**.6** operation manual (***).

**3.2.10 Documentation on control systems:**

**.1** circuit connection diagram (**);

**.2** electrical schematic diagram (*);

**.3** technical background (**);

**.4** testing program (**);

**.5** operational documents.

**3.2.11 Documentation on buoyancy materials:**

**.1** drawings of buoyancy units (**);

**.2** technical backgrounds (**);

**.3** testing methods (**);

**.4** specifications for materials of buoyancy units (**).

**3.2.12 Documentation on emergency surfacing and recovery system:**

**.1** structural drawing of emergency power supply (*);

**.2** circuit diagram with the list of system elements (*);

**.3** calculation of emergency power supply output (*);

**.4** technical background (**).

**3.2.13 Documentation on handling system.**

The scope of technical documentation submitted to the Register for review and approval shall not be less than stated in 1.4 of the Rules for the Cargo Handling Gear of Sea-Going Ships.

In addition, the following documentation shall be submitted:

**.1** Operation Manual for the handling system as a whole and individual machinery and systems including main and emergency electrical, pneumatic and hydraulic power sources containing instructions on operational checks and planned maintenance scheme and specifying the expected service life of important components and equipment (***);

**.2** diagram or logic diagram of work procedure for intended use of the handling system. Circuit diagrams illustrating operation of systems with details on the systems. The diagrams shall schematically show the arrangement of pipelines and include details on controls and power supply (**);

**.3** information on operating weight of UUV and TMS with indication of all hydrostatic and dynamic characteristics which shall be taken into account for strength calculations of the handling system's parts (***);

**.4** drawings, specifications and calculations of the systems and devices used for lowering and lifting operations and emergency recovery of UUV and TMS on board the carrier ship (**);

**.5** calculations of electrical load in the main and emergency modes of the handling system (**);

**.6** data on emergency power sources (***).

The technical documentation may be accompanied with the protocols of previously performed tests and available statements and certificates.

Upon review of the technical documentation submitted, the applicant shall agree and submit for approval the test program.

# PART II. HULL STRUCTURES

## 1 GENERAL

### 1.1 APPLICATION

The requirements of this Part of the Rules apply to UUV hulls, load-bearing frames, tanks and pressure vessels manufactured of low-alloy steels with yield stress $R_{eH}$ ≤690 MPa, and operated under external or internal hyperbaric pressure, manufactured by means of welding and other alternative methods.

The application of the methods specified in this Part of the Rules when using low-alloy steels with yield stress $R_{eH}$ >690 MPa or austenitic high-alloyed steel, titanium and aluminum alloys, composite materials, as well as the application of glass-reinforced plastic for the pressure hull and equivalent structures may be allowed subject to agreement with the Register in each case. Besides steel, other materials may be used for construction of the external hull as agreed with the Register.

## 1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of the Rules are given in the General Regulations for the Classification and Other Activity relating to UUV.

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

Allowable stresses $[\sigma]$ mean the maximum values of stresses, under which the strength is maintained.

Test pressure $P_t$ means the maximum pressure, by which the structure is tested after construction.

Critical pressure $P_c$ means an external pressure, at which the hull or its elements can be fractured (buckled) under single loading.

Local membrane stresses $\sigma_1$ mean the through-the-thickness average increased stresses typical for small areas (e.g. in way of openings).

Mechanical properties of material mean the ultimate strength (tensile strength) $R_m$, yield stress $R_{eH}$, Young's modulus $E$, Poisson's ratio $v$. The value equal to the proof stress $R_{p0,2}$ is introduced in calculations for materials lacking a yield area. For the purpose of this Part of the Rules, it is assumed that for metal hulls $v$ = 0,3, and for steel $E$ = 2×10⁵, MPa.

General membrane stresses $\sigma_0$ mean the through-the-thickness average stresses encompassing the most part of the hull volume, average stresses in the smooth cylindrical or spherical shell, average stresses at the mid-point of the spacing of a cylindrical shell stiffened by frames, etc.

Pressure resistant structures of UUV mean the pressure hull, pressure tanks and other UUV elements carrying and balancing loads due to excessive pressure.

Operating diving depth $H_{op}$ means the maximum depth, at which normal operation of the unmanned underwater vehicle is possible.

It is assumed that the total number of submergences to the operating depth during the operation of UUV shall not exceed 1000. When calculating the conventional number of submergences, proceeding from the above condition, on the basis of the number of submergences to different depths the following formula shall be used

$$n_{conv} = \sum_i n_{H_i} \left(H_i / H_{op}\right)^{m_i} \leq 1000 \qquad (1.2)$$

provided that $\sum_i n_{H_i} \leq$ 50000,

where $H_i$ = maximum depth in the narrow range of depths (e.g. from $0{,}8H_{op}$ to $0{,}9H_{op}$);
$n_{H_i}$ = number of submergences in the narrow range of depths;
$m_i$ = exponent determined by the formula

$$m_i = 3/(2H_i/H_{op} + 1).$$

Summation in Formula (1.2) is made with respect to all the depth ranges.

When counting up the number of cycles at the repeatedly changed depth in the course of sailing without surfacing, the real spectrum shall be reduced to the simplified one with an obvious error on the safe side.

Where it is necessary to ensure the conventional number of submergences over 1000, the possibility of doing it shall be supported by a special calculation for the cyclic loading according to the procedure approved by the Register. In this case, to prevent corrosion cracking of the hull under cyclic loading, only those hull materials are allowed for use, which have proved their effectiveness under sea conditions during at least 5 years as part of other ship's hull structures repeatedly loaded. The appropriate supporting documents shall be submitted to the Register by the designer of the submersible.

Operating pressure $P_{op}$ for UUV means the seawater pressure exerted on UUV and corresponding to the operating diving depth.

D e s i g n t e m p e r a t u r e $T_d$ means the lowest temperature, at which normal operation of the underwater vehicle is possible. $T_d$ is specified proceeding from the expected operating conditions. The requirements of the Rules for materials have been worked out for $T_d \geq -5 + 35$ °C. If, due to the operating conditions, $T_d <-$ 5 °C is possible, the requirements for the materials used shall be agreed by the Register.

T o t a l s t r e s s e s $\sigma^t$ mean the maximum stresses, which take into account the stresses due to the hull structure bending on stiff members, e.g. in way of frames. The local concentration of stresses near bores, weld reinforcements, etc. are ignored.

## 1.3 SCOPE OF SURVEYS

**1.3.1** The general provisions for the survey of the hull are set forth in the General Regulations for the Classification and Other Activity relating to UUV.

**1.3.2** The following hull structures are subject to the RS survey during construction:

**.1** pressure hull and other pressure-resistant structures (tanks, containers, etc.) which take up pressure;

**.2** load-bearing frame;

**.3** foundations for securing equipment with a mass more than 15 kg (regardless of the position).

## 1.4 GENERAL REQUIREMENTS

**1.4.1** In general, the hull structure of UUV may be of two types:

**.1** structures consisting of one or several pressure (tight) hulls consequently linked with the possibility of their disassembly. Inside and outside of the pressure hull other UUV structural elements, including load-bearing permeable structures are located.

**.2** structures in a form of completely welded or detachable base frame, on or in which pressure (tight) containers with equipment placed in them, buoyancy structures (buoyancy units) and other structural elements of UUV are installed.

Other types of load-bearing hull structures shall be agreed with the Register.

**1.4.2** The pressure hull of the unmanned underwater vehicle shall include:

**.1** hull (shell ring);
**.2** frames (where necessary);
**.3** flanges;
**.4** covers;
**.5** sealing rings;
**.6** cable penetrations;
**.7** cargo clamps (where necessary);
**.8** fasteners.

**1.4.3** The framed (load-bearing) structure of the UUV shall contain:

**.1** trusses;
**.2** base frames;
**.3** fasteners.

N o t e . The set of pressure-resistant and framed load-bearing structures of the unmanned underwater vehicle shall be specified during design and indicated in the structural drawings.

## 1.5 PURPOSE REQUIREMENTS

**1.5.1** The pressure-resistant and framed load-bearing structures of unmanned underwater vehicles shall provide:

**.1** arrangement, loading/unloading and securing of the equipment;
**.2** compensation of excessive pressure;
**.3** tightness of detachable connections and electrical outputs;
**.4** possibility to perform maintenance and periodic checks of the installed equipment;
**.5** securing of rigging arrangements (gripping elements of cargo handling gear).

## 1.6 TECHNICAL REQUIREMENTS

**1.6.1** The pressure-resistant and framed load-bearing structures of unmanned underwater vehicles shall operate in sea water within the range of operating depths.

**1.6.2** The pressure-resistant and framed load-bearing structures of unmanned underwater vehicles shall ensure arrangement and reliable securing of the equipment.

**1.6.3** All applied materials of pressure-resistant and framed load-bearing structures of the unmanned underwater vehicles shall meet the requirements for strength, stiffness and corrosion resistance under environmental impact, variable temperatures and other external factors during the entire operating life.

**1.6.4** Elements shall be provided to allow for handling the pressure-resistant and load-bearing structures of UUV.

**1.6.5** The cable penetrations shall structurally provide:

**.1** tight joint of connectors of UUV electrical equipment;

**.2** tightness of the pressure-resistant structure in case of disengagement (damage) of one of the connectors.

## 1.7 REQUIREMENTS FOR SURVIVABILITY AND STABILITY TO EXTERNAL IMPACTS

**1.7.1** The shock resistance of pressure-resistant and load-bearing structures of UUV shall provide stability to the environmental impact during operation.

**1.7.2** The pressure-resistant and permeable load-bearing structures shall provide a reliable UUV operation during the entire service life in conditions and under loads established by the specification.

## 1.8 STRUCTURAL REQUIREMENTS

**1.8.1** The pressure-resistant and permeable load-bearing structures of UUV shall be manufactured of durable, shock-resistant, corrosion-resistant materials.

## 1.9 REQUIREMENTS FOR OPERATION, STORAGE, EASE OF MAINTENANCE AND REPAIR

**1.9.1** The pressure-resistant and framed load-bearing structures of UUV shall maintain their performance indicators throughout the entire service life.

*APPENDIX*

## CALCULATION PROCEDURE

### GENERAL

The pressure hull of the unmanned underwater vehicle shall be calculated in elasto-plastic arrangement using material model given in (1):

$$\bar{\sigma} = K_0 \cdot \bar{e}_p^{m_0}, \quad (1)$$

$$\bar{e}_p = ln(1 + \varepsilon_p) \quad (2)$$

where $\bar{\sigma}$ — true stress in the sample cross-section under tension or compression;
$\bar{e}_p$ — plastic constituent of true deformation;
$\varepsilon_p$ — plastic (scleronomic) deformation;
$K_0$, $m_0$ — constants of the material.

### 1 STRENGTH STANDARDS

**1.1** Condition of strength reads as:

$$\frac{[\sigma]}{\sigma} \geq 1 \quad (3)$$

where [σ] = allowable stresses, in MPa;
σ = acting stresses, in MPa.

1.2 Allowable stresses for hulls loaded by external pressure are assumed equal to:
– general membrane compressive stresses:

$$[\sigma_c^0] = \frac{\sigma_{0,2}}{n_{YC}}, \quad (4)$$

– general membrane tensile stresses:

$$[\sigma_t^0] = \frac{\sigma_{0,2}}{n_{YT}}, \quad (5)$$

– local membrane stresses:

$$[\sigma_l] = 1{,}1 \cdot [\sigma^0], \quad (6)$$

– total stresses:

$$[\sigma_l] = 1{,}2 \cdot [\sigma^0] \quad (7)$$

where $n_{YC}$ = 1,5 = safety factor for compressive stresses;
$n_{YT}$ = 2,0 = safety factor for tensile stresses.

In case of compressive and tensile stresses in any section of the hull:

$$\sigma_t \leq [\sigma_t], \quad (8)$$

$$|\sigma_t| + |\sigma_c| \leq [\sigma_c], \quad (9)$$

**1.3** For stability the safety factor is equal to $n_s$ = 1,1.
**1.4** Analytical dependency.
**1.4.1** Strength of pressure hull with equipment.
General membrane stresses at the mid-point of frame spacing:

$$\sigma_2^0 = \frac{k_2^0 \cdot P \cdot r}{S}, \quad (10)$$

Total stresses at the transverse section in way of the frame:

$$\sigma_1^t = \frac{k_1 \cdot P \cdot r}{S}, \tag{11}$$

Radially acting stresses at the frame web in way of shell plating:

$$\sigma_{fr}^0 = k \cdot \frac{P}{1-\frac{Z_0}{r}} \cdot \frac{F}{S} \cdot S_{fr}, \tag{12}$$

Difference of principal stresses at the external frame web in way of shell plating:

$$\sigma_{fr}^0 = k \cdot \frac{P \cdot r}{S} \cdot \left(1 + \frac{F}{r \cdot S_{fr} \cdot \left(1 + \frac{Z_0}{r}\right)}\right) \tag{13}$$

where $S_{fr}$ = thickness of the frame web, in mm;
$F$ = cross-sectional area of the frame profile, in m$^2$;
$Z_0$ = distance from the frame center of gravity to the median surface of shell, in mm;
$Z_{fr}$ = depth of the frame measured from the median surface of the shell up to the free edge, in mm;
$k$, $k_1$, $k_2^0$ = correction factor used in stress calculations.

$$u = 0{,}642 \cdot \frac{l}{\sqrt{r \cdot S}}, \tag{14}$$

$$\beta = \frac{l \cdot S \cdot \left(1-\frac{Z_0}{r}\right)}{F}, \tag{15}$$

$$k_2^0 = \begin{cases} 1, & \text{at } u > 4{,}5 \\ 1 - \frac{F_4}{1+\beta \cdot F_1}, & \text{at } 0{,}6 \le u \le 4{,}5, \\ \frac{\beta+0{,}15}{1+\beta}, & \text{at } u < 0{,}6 \end{cases} \tag{16}$$

$$k_1 = \begin{cases} 0{,}5 + 1{,}54 \cdot \frac{u}{u+\beta}, & \text{at } u > 4{,}5 \\ 0{,}5 + \frac{F_2}{1+\beta \cdot F_1}, & \text{at } 0{,}6 \le u \le 4{,}5 \\ 0{,}5 + 1{,}03 \cdot \frac{u^2}{1+\beta}, & \text{at } u < 0{,}6 \end{cases}, \tag{17}$$

$$k = \begin{cases} 0{,}85 \cdot \frac{\beta}{u+\beta}, & \text{at } u > 4{,}5 \\ 0{,}85 \cdot \beta \cdot F_1 \cdot \frac{\beta}{u+\beta \cdot F_1}, & \text{at } 0{,}6 \le u \le 4{,}5, \\ 0{,}85 \cdot \frac{\beta}{1+\beta}, & \text{at } u < 0{,}6 \end{cases} \tag{18}$$

$$u_1 = u \cdot \sqrt{1 - \frac{1}{2 \cdot u}}, \tag{19}$$

$$u_2 = u \cdot \sqrt{1 + \frac{1}{2 \cdot u}}, \tag{20}$$

$$F_1 = \sqrt{1 - \frac{1}{4 \cdot u^2}} \cdot \frac{cosh(2u_1) - cos(2u_2)}{u_2 \cdot sinh(2u_1) + u_1 \cdot sin(2u_2)}, \tag{21}$$

$$F_2 = 1{,}54 \cdot \frac{u_2 \cdot sinh(2u_1) - u_1 \cdot sin(2u_2)}{u_2 \cdot sinh(2u_1) + u_1 \cdot sin(2u_2)}, \tag{22}$$

$$F_4 = 1{,}7 \cdot \frac{u_1 \cdot cosh(u_1) \cdot sin(u_2) + u_2 \cdot sinh(u_1) \cdot cos(u_2)}{u_2 \cdot sinh(2u_1) + u_1 \cdot sin(2u_2)}, \tag{23}$$

**1.4.2** Stability of pressure hull with equipment.

**1.4.2.1** Critical pressure of plating between the frames shall be calculated by the formula:

$$p_{cr} = P_{1c} = \eta^{'} \cdot P^{'}_{1}, \tag{24}$$

$$P^{'}_{1} = \begin{cases} 0{,}59 \cdot E \cdot \left(\frac{S}{r}\right)^2 \cdot \frac{\left(1 + 0{,}4/u_k + 0{,}2/u_k^2\right)}{k_2^0 \cdot u}, \text{ at } 1 < u < u_g \\ 0{,}944 \cdot E \cdot \left(\frac{S}{r}\right)^2, \text{ at } u \leq 1 \end{cases} \tag{25}$$

$$u = 0{,}642 \cdot \frac{l}{\sqrt{r \cdot S}}, \tag{26}$$

$$u_g = \frac{2{,}15 \cdot r}{S}, \tag{27}$$

$$u_k = \frac{u}{\left(2 - 1/k_2^0\right)}, \tag{28}$$

$$\eta^{'} = \frac{\eta_k}{1 + 3 \cdot \left(\frac{\eta_k}{\eta_g} - 1\right) \cdot \left(\frac{u - 0{,}1 \cdot u_g}{0{,}9 \cdot u_g}\right)^2 \cdot \left(1 - \frac{2}{3} \cdot \frac{u - 0{,}1 \cdot u_g}{0{,}9 \cdot u_g}\right)}, \tag{29}$$

$$\eta_k = \frac{\eta_1}{\sqrt[4]{1 + \frac{2}{3} \cdot [(1 + \bar{f}_1) \cdot \eta_1 \cdot \bar{\sigma}]^4}}, \tag{30}$$

$$\eta_g = \frac{1}{2} \cdot \left[ \frac{1}{\sqrt[4]{1 + \frac{9 \cdot \bar{\sigma}^4}{16}}} + 5{,}46 \cdot \bar{f}_1 + \frac{2}{\sqrt{3} \cdot \bar{\sigma}} - \sqrt{\left( \frac{1}{\sqrt[4]{1 + \frac{9 \cdot \bar{\sigma}^4}{16}}} + 5{,}46 \cdot \bar{f}_1 + \frac{2}{\sqrt{3} \cdot \bar{\sigma}} \right)^2 - \frac{8}{\sqrt{3} \cdot \bar{\sigma} \cdot \sqrt[4]{1 + \frac{9 \cdot \bar{\sigma}^4}{16}}}} \right], \tag{31}$$

$$\bar{\sigma} = \frac{k_2^0 P^{'}_{1} \cdot R}{S \cdot R_{eH}}, \tag{32}$$

$$\eta_1 = \frac{1}{1 + 1{,}35 \cdot \frac{\bar{f}_1}{\left(1{,}57 \cdot \bar{f}_1 + 1\right)^{2/3}}}, \tag{33}$$

$$\bar{f}_1 = \frac{f_1}{\delta} \tag{34}$$

where $P'_1$ = theoretical critical buckling pressure of smooth cylindrical shell, in MPa;
$r$ = radius of the median surface of the cylindrical shell, in mm;
$l$ = length of cylindrical shell, in mm;
$S$ = thickness of cylindrical shell wall, in mm;
$k_2^0$, $\eta'$, $\eta_1$ = correction factors.
$f_1$ = maximum deviation of cylindrical surface from the regular round form.

**1.4.2.2** For stiffened cylindrical shell the condition of stability reads as:

$$P \leq P_{1c}/n_s, \tag{35}$$

$$P \leq P_{2c}/n_s \tag{36}$$

where $P_{1c}$ = critical buckling pressure of smooth shell between frames, in MPa (defined by formulae (24) — (34));
$P_{2c}$ = critical buckling pressure of smooth shell together with the frames;
$n_s$ = safety factor for stability.

$$P_{2c} = \eta'' \cdot P'_2, \tag{37}$$

$$P'_2 = \frac{E}{n^2 - 1 + \frac{\alpha_1^2}{2}} \cdot \left[ \begin{array}{l} \frac{\bar{I}_0 \cdot (n^2-1)^2}{r^3 \cdot l} + \frac{S^3 \cdot (n^2 - 1 + \alpha_1^2)^2}{10{,}9 \cdot r^3} + \frac{S}{r} \cdot \frac{\alpha_1^4}{(n^2+\alpha_1^2)^2} + \\ + \frac{F \cdot \left(1 - \frac{Z_0}{R}\right)}{l \cdot r} \cdot \frac{Z_0}{r - Z_0} \cdot (n^2 - 1) + \frac{(0{,}3 \cdot n^2 - \alpha_1^2) \cdot \alpha_1^2}{(n^2+\alpha_1^2)^2} \end{array} \right] \tag{38}$$

where $l$ = spacing of the shell;
$n$ = number of buckling waves along the circumference.

$$\alpha_1 = \frac{\pi \cdot r}{L_d} \tag{39}$$

where $L_d$ = design length of the cylindrical shell (taken between two flanges);

$$\bar{I}_0 = I_0 \cdot \left(1 + 3 \cdot \frac{Z_0}{r} + 6 \cdot \frac{Z_0^2}{r}\right) \tag{40}$$

where $I_0$ = intrinsic moment of inertia of the frame web section;

Correction factor to the calculation formula of critical pressure:

$$\eta'' = \frac{1}{2} \cdot \left[ 1 + \frac{1+m}{\sqrt[4]{1+\frac{2 \cdot \bar{\sigma}^4}{3}}} - \sqrt{\left(1 + \frac{1+m}{\sqrt[4]{1+\frac{2 \cdot \bar{\sigma}^4}{3}}}\right)^2 - \frac{4}{\sqrt[4]{1+\frac{2 \cdot \bar{\sigma}^4}{3}}}} \right], \tag{41}$$

$$m = 0{,}5 \cdot \frac{E \cdot |f_2 \cdot Z_1| \cdot (n^2-1) \cdot \delta}{k \cdot P'_2 \cdot r^3} \cdot C_1, \tag{42}$$

$$Z_1 = Z_{fr} - \frac{Z_0}{1+\beta_1} \cdot \frac{1 - \frac{Z_{fr}}{r}}{1 - \frac{Z_0}{r}}, \tag{43}$$

$$\bar{\sigma} = max\left( \frac{k_2^0 \cdot P'_2 \cdot r}{S \cdot \sigma_m}; \sqrt[4]{\frac{3}{2}} \cdot \frac{k \cdot P'_2 \cdot r}{\left(1 - \frac{Z_{fr}}{r}\right) \cdot S \cdot \sigma_m} \right), \tag{44}$$

$C_1 = 1$ for this structure type.

# PART III. SYSTEMS AND PIPING

## 1 GENERAL

### 1.1 APPLICATION

**1.1.1** The requirements of this Part cover pressure compensation system of cable runs and systems of different purposes.

## 1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of the Rules are given in the General Regulations.

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

**1.2.1 Definitions.**

Hydraulic system of UUV is a set of special equipment, valves and pipes unified structurally and functionally in order to provide movement of hydraulically-driven actuating systems by means of pressurized working fluid.

Oil-filled cable route means a hollow flexible pipe with cables routed inside (harnesses of electrical cables) filled with electrically neutral (insulating) working fluid.

Pressure compensator means a device providing storage of a reserve volume of the working fluid required to compensate for changes in its volume in cable routes, pipelines and spaces of the hydraulic system equipment when environmental parameters change, as well as formation of excessive pressure in the system to avoid penetration of sea water into the system.

Junction box means a tight container in a form of a body with a cover providing branching of several cables running in one route to the required number of parallel cable routes or for joining an oil-filled cable route with sealed outboard cables.

Sealing disconnector is a device providing possibility to detach an oil-filled cable route while maintaining its tightness for quick replacement of parts of UUV equipment.

**1.2.2 Explanations.**

The present Rules use pressure compensation system to provide watertightness (protection against sea water) of electrical connections running inside cable routes between the equipment and devices of the unmanned underwater vehicle.

The pressure compensation system allows the use of cables not designed for exposure to excessive pressure and contact with sea water as electrical connections.

## 1.3 SCOPE OF SUPERVISION

**1.3.1** The Register supervision covers the following products and principal materials being a part of the pressure compensation system: oil-filled cable routes, pressure compensators as well as other elements (junction boxes, sealing disconnectors) that may be included in the system depending on the equipment configuration.

## 1.4 GENERAL REQUIREMENTS

**1.4.1** Main materials used for manufacture of elements for piping systems shall comply with the purpose requirements and applicable RS requirements.

**1.4.2** Piping systems shall be designed and manufactured using state-of-art principles and technologies.

**1.4.3** Piping systems shall be designed for working pressure and tested with test pressure.

**1.4.4** Fluid with dielectric properties shall be used to fill the pressure compensation system.

**1.4.5** When filling the pressure compensation system, the minimum possible air volume in cable routes shall be ensured. The procedure for evacuating the pressure compensation system shall be specified in the technical documentation and in the Operation Manual.

## 1.5 REQUIREMENTS FOR HYDRAULIC SYSTEMS

**1.5.1** As a rule, the hydraulic system shall include:

**.1** pump-accumulator units consisting of pumps, hydraulic accumulators, hydraulic transformers, valve switches, reservoirs, bottles, etc.;

**.2** filters, valves, connectors;

**.3** pipelines;

**.4** instrumentation;

**.5** automation means.

The hydraulic system of the unmanned underwater vehicles does not include elements of the hydraulic drives of the actuators.

**1.5.2** The hydraulic system shall provide:

**.1** tightness to prevent leakage of working fluid and penetration of sea water into the system;

**.2** operation of system elements on the operating depth both in fresh and sea water;

**.3** safety and ease of installation and maintenance;

**.4** possibility of collecting and pumping off the working fluid eliminating the possibility of spills into the environment.

**1.5.3** Removable actuators shall be connected to the hydraulic system via quick-detachable arrangements.

**1.5.4** Operating documentation shall contain information on tightness control methods and measures to eliminate possible spills of working fluid.

# PART IV. PROPULSION AND STEERING COMPLEX

## 1 GENERAL

### 1.1 APPLICATION

**1.1.1** The requirements of this Part cover the propulsion and steering complex including its components and control elements and apply during review of technical documentation and supervision during manufacture and testing of the specified complex.

## 1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of these Rules are given in the General Regulations.

## 1.3 SCOPE OF SUPERVISION

**1.3.1** The Register supervision covers the principal products and materials being a part of the propulsion and steering complex.

## 1.4 GENERAL REQUIREMENTS

**1.4.1** The main components of the propulsion and steering complex shall comply with the purpose requirements including climatic ones.

**1.4.2** The equipment of propulsion and steering complex shall include, as a rule, the following elements of the unmanned underwater vehicle:

driven propulsion devices;

cable network and connectors.

**1.4.3** Arrangement, quantity and output of propulsion devices shall be specified by the purpose requirements of the unmanned underwater vehicle.

**1.4.4** The propulsion devices may be driven hydraulically or electrically.

**1.4.5** As regards the electromagnetic compatibility and structure, the propulsion and steering complex shall meet the applicable requirements of the Russian Maritime Register of Shipping in compliance with the Rules for the Classification and Construction of Sea-Going Ships.

**1.4.6** Propellers projecting beyond the hull lines shall be protected by special nozzles.

# PART V. ENERGY SUPPLY SYSTEM

## 1 GENERAL

### 1.1 APPLICATION

**1.1.1** The requirements of this Part cover the energy supply system of the unmanned underwater vehicles and their components and control elements and apply during review of the technical documentation and supervision during manufacture and testing of the specified complex.

## 1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of the Rules are given in the General Regulations.

## 1.3 SCOPE OF SUPERVISION

**1.3.1** The Register supervision covers the energy sources and distribution, protection, switch and power transmitting devices.

## 1.4 GENERAL REQUIREMENTS

**1.4.1** The main components of the energy supply system shall meet the purpose requirements and shall be approved by the Register.

**1.4.2** The equipment and systems of autonomous underwater vehicles shall be powered from electrical power sources (both AC and DC sources may be used). The energy supply system of unmanned underwater vehicles shall contain main and emergency electric power sources. Electrical power parameters and source capacity are determined based on the power needed to perform the set program by the vehicle, the volume reserved for arrangement of the source, technical features of the source and switch capability of the protection apparatus.

The main source of electrical power may be accumulator batteries or equipment specified in 1.4.3.

**1.4.3** The equipment and systems of ROV may be supplied with electrical power from external sources taking into account features of the communication tether cable or umbilical such as length, cross sectional area of cables, material of cores, own inductivity and capacity.

**1.4.4** The energy supply system of unmanned underwater vehicles shall ensure supply of electrical power consumers with the specified parameters during the regulated operation time and service life under all operating modes.

Rated capacity of the source in AUV shall be sufficient for:

supply of the consumers in different operation modes;

provision of full and cruising speed taking into account supply of the minimum necessary number of UUV equipment and systems during the time specified by the UUV application model.

The sufficiency of the source energy is estimated considering the UUV application model (intended mission).

**1.4.5** Electrical power shall be distributed among the consumers of power equipment by connection via feeding connectors to the contacts of power connector of electrical power source.

**1.4.6** Arrangement of electrical supply of UUV systems with electrical energy whose parameters are different from those of the energy supply system shall be carried out by own means of these systems.

**1.4.7** AUV power source shall comprise a system performing functions of monitoring, control and protection of the source and providing communication with the upper level control system. The functions of monitoring, protection and control of the source as well as distribution of electric energy to the consumers may be implemented in a single structure.

**1.4.8** Arrangement and number of components of the energy supply system are determined by the UUV purpose requirements.

**1.4.9** The possibility of recharging and periodical charging of UUV renewal energy sources shall be provided by a contact or remote method.

**1.4.10** In an emergency mode of UUV operation (if provided), electrical supply of consumers whose operation is provided in this mode shall be ensured from emergency electrical power source.

**1.4.11** Components of the energy supply system shall be arranged considering the provision of:

ease and safety of maintenance of all components;

secure fastening of the components to suit operating and maintenance conditions;

protection of components against ingress of sea water;

protection of components against vertical and horizontal movements using non-conductive and corrosion-resistant materials.

**1.4.12** The energy supply system as regards electromagnetic compatibility shall meet the applicable requirements in Part XI "Electrical Equipment" of the Rules for the Classification and Construction of Sea-Going Ships.

# PART VI. NAVIGATIONAL EQUIPMENT

## 1 GENERAL

### 1.1 APPLICATION

**1.1.1** The requirements of the present Part of the Rules apply to navigational equipment of the unmanned underwater vehicles and carrier ships.

## 1.2 DEFINITIONS AND EXPLANATIONS

**1.2.1** Definitions and explanations relating to the navigational equipment not covered in this Part are given in Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships, and those relating to the general terminology of the Rules — in the General Regulations of these Rules.

**1.2.2** The following definitions are adopted in this Part of the Rules:

**.1** inertial navigation system is an autonomous navigation system based on properties of body inertia that does not use external references, signals and data coming from outside;

**.2** sonar navigation system is a system based on the use of receipt and emission of sonar signals to specify the coordinates of the unmanned underwater vehicle in interaction with bottom transponder beacons or sonar system of the carrier ship.

**1.2.3** The following abbreviations are adopted in this Part of the Rules:

CS — control system;

AWP — automated working place;

SNS — sonar navigation system.

## 1.3 SCOPE OF SURVEYS

**1.3.1** General provisions concerning the procedure of survey of the communication equipment are stated in the General Regulations for the Classification and Other Activity, in Part I "Classification" of these Rules and Part V "Navigational Equipment" of the Rules for the Equipment of Sea-Going Ships.

**1.3.2** The following equipment shall be subject to the RS survey during manufacture, installation and in operation:

**.1** gyrocompass;

**.2** absolute log and water speed log;

**.3** inertial navigation system;

**.4** sonar navigation system;

**.5** depth gauge;

**.6** echo sounder (altimeter);

**.7** navigational complex (navigational digital computer);

**.8** control consoles for navigational equipment;

**.9** other not listed above navigational equipment that may constitute a part of an unmanned underwater vehicle.

**1.3.3** Technical requirements for navigational equipment, its location and installation in the unmanned underwater vehicle which are not mentioned in this Part of the Rules, as well as the scope of surveys of this equipment shall be agreed with the Register.

## 2 SCOPE OF NAVIGATIONAL EQUIPMENT

### 2.1 GENERAL REQUIREMENTS

**2.1.1** Navigational equipment of unmanned underwater vehicles shall be capable of outputting navigational parameters (current position coordinates) and motion parameters (heel, trim, heading, gradients of heel, trim, heading, etc.).

## 2.2 LIST OF NAVIGATIONAL EQUIPMENT

**2.2.1** The UUV navigational equipment, as a rule, shall include:

**.1** gyrocompass;
**.2** absolute log and water speed log;
**.3** inertial navigation system;
**.4** sonar navigation system (SNS);
**.5** depth gauge;
**.6** echo sounder (altimeter);
**.7** navigational digital computer.

**2.2.2** The composition of navigational equipment to be installed on the unmanned underwater vehicle shall be determined by the class, UUV mass and purpose requirements. The typical list of navigational equipment is given in Table 2.2.2.

Table 2.2.2

| Class | Light | Middle | Heavy | |
|---|---|---|---|---|
| Mass in kg | up to 300 | 300 to 1000 | 1000 to 5000 | over 5000 |
| Gyrocompass | + | + | + | + |
| Depth gauge | + | + | + | + |
| Absolute log | − | + | + | + |
| Water speed log | − | + | + | + |
| Inertial navigation system | − | + | + | + |
| Echo sounder (altimeter) | − | + | + | + |
| Scanning sonar | + | + | + | + |
| Note. The list of the navigational equipment may be amended for different classes of unmanned underwater vehicles depending on the UUV purpose requirements. | | | | |

## 2.3 SOURCES OF ELECTRICAL POWER FOR NAVIGATIONAL EQUIPMENT

**2.3.1** The source of electrical power for AUV is an accumulator battery or other air-independent autonomous source of electrical power.

**2.3.2** The source of electrical power for heavy class ROV is the electric power plant located on the carrier ship from which the electrical power is supplied to ROV via the cable.

For ROV of light or middle class, the accumulator battery or another air-independent autonomous source of electrical power located directly on ROV may be used as a source of electrical power.

## 3 REQUIREMENTS FOR NAVIGATIONAL EQUIPMENT

### 3.1 UUV NAVIGATIONAL EQUIPMENT

**3.1.1** Navigational equipment shall meet the UUV purpose requirements, including climatic ones, and shall be designed to provide ease and availability for inspection and maintenance.

**3.1.2** Navigational equipment shall be designed considering integration with other systems and complexes.

**3.1.3** The gyrocompass shall determine the direction of movement with a precision and frequency of data updating sufficient to fulfill specified UUV navigation parameters.

The gyrocompass shall be equipped with necessary watertight connectors for data transmission to the ROV control unit, connectors for power supply and time synchronization signal.

**3.1.4** Absolute log and water speed log shall provide determination of UUV speed with an error not worse than the following values:

**.1** for absolute log — 0,05 of the current speed of the unmanned underwater vehicle;

**.2** for water speed log — 0,1 of the current speed of the unmanned underwater vehicle.

The instruments shall be fitted with the necessary sealed interfaces for data transfer to the ROV control unit, and connectors for power supply.

**3.1.5** The inertial navigation system shall be capable of generating navigational solutions and transmitting them to the navigational digital computer for stabilization of the motion in terms of heading, heel and trim control as well as position keeping. The inertial navigation system shall provide generation of solutions with parameters not worse than as follows:

**.1** error of heading angle keeping not more than 5° for 1 h of operation;

**.2** error of determination of heel and trim angles not more than 0,5°;

**.3** error of coordinate calculation not more than 5,0 % of the distance traveled.

**3.1.6** The navigational system (navigational digital computer) shall process the data from the inertial navigation system, log, depth gauge to generate integrated information about spatial position of the unmanned underwater vehicle at least once per second and shall provide:

**.1** parallel, in uniform time, processing of information from navigational devices and determination of spatial position of the unmanned underwater vehicle and features of its motion;

**.2** formation of output information on spatial position of the unmanned underwater vehicle and features of its motion for transfer via communication link to the carrier ship;

**.3** control of information transmission to the carrier ship via communication link.

**3.1.7** The sonar navigational system of the unmanned underwater vehicle shall ensure that the UUV coordinates are updated when interacting with bottom transponder beacons or through the sonar system of the carrier ship.

**3.1.8** In addition to the pressure (depth) monitoring, the pressure sensor (depth gauge) is used to control UUV diving depth stabilization. The information on pressure is transmitted to the UUV control system. The depth gauge shall determine depth with parameters not worse than as follows:

**.1** resolution capability: not less than 0,05 of UUV diving depth;

**.2** depth range: from surface to the operating UUV diving depth;

**.3** data update frequency: not less than 1 Hz.

**3.1.9** The echo sounder (altimeter) shall provide determination of distance from the lower UUV hull line to the sea bottom with parameters not worse than as follows:

**.1** resolution capability: not less than 0,2 m;

**.2** distance to the sea bottom: not less than 50 m.

**3.1.10** The echo sounder system (scanning sonar or sector sonar) is installed on the unmanned underwater vehicle and shall provide circular or sector scanning of the surrounding space to detect navigational obstacles and other items on the sea bottom and in water column.

The technical specifications of the echo sounder system shall be not worse than those listed below:

**.1** in long range target detection mode the maximum detection distance shall be not less than 300 m at angular height of the acoustic ray of 20°;

**.2** in near range detected target close-up examination mode the maximum detection distance shall not be less than 100 m at angular height of the acoustic ray of 40°;

**.3** minimum range resolution shall be 10 m;

**.4** minimum size of detectable metal object shall not be less than 0,5 m.

# 4 ARRANGEMENT OF NAVIGATIONAL EQUIPMENT

## 4.1 ARRANGEMENT OF EQUIPMENT ON AUV

Arrangement of navigational equipment shall provide ease and availability for inspection and maintenance.

Arrangement of navigational equipment shall be specified by AUV purpose requirements.

## 4.2 ARRANGEMENT OF EQUIPMENT ON ROV

Controls and indication means of ROV navigational equipment shall be located in control stations of the carrier ship.

# PART VII. COMMUNICATION EQUIPMENT

## 1 GENERAL

### 1.1 APPLICATION

The requirements of this Part of the Rules apply to radio and sonar equipment of unmanned underwater vehicles and carrier ships as well as to cable communication equipment of ROV and carrier ships.

## 1.2 DEFINITIONS AND EXPLANATIONS

**1.2.1** Definitions and explanations relating to the radio equipment not specified in this Part are given in Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships, and those relating to the general terminology of the Rules — in the General Regulations of these Rules.

**1.2.2** The following definitions are adopted in this Part of the Rules:

Autonomous search radio complex is a set of technical means (antenna module, electronic unit and autonomous source of electrical power) fitted on the unmanned underwater vehicle and providing information exchange with the carrier ship via radio channel when the unmanned underwater vehicle is afloat.

**1.2.3** The following abbreviations are adopted in this Part of the Rules:

UUV — unmanned underwater vehicle;

AUV — autonomous underwater vehicle;

ROV — remotely operated vehicle;

BTB — bottom transponder beacon;

CS — control system;

SCS — sonar communication system.

## 1.3 SCOPE OF SURVEYS

**1.3.1** General provisions for the procedure of survey of the communication equipment are given in the General Regulations for the Classification and Other Activity, in Part I "Classification" of these Rules and Part IV "Radio Equipment" of the Rules for the Equipment of Sea-Going Ships.

**1.3.2** Subject to survey by the Register during manufacture, installation and in operation are:

**.1** emergency sonar beacons;

**.2** emergency receivers of sonar signals on the carrier ship;

**.3** autonomous search radio complex;

**.4** communications sonar systems for receipt-transmission of signals and data;

**.5** cable communication equipment;

**.6** communication equipment control consoles;

**.7** other equipment and communication systems not listed above, that may be a part of the unmanned underwater vehicle.

**1.3.3** Technical requirements for radio and sonar equipment, its location and installation in the unmanned underwater vehicles, and ROV cable communication equipment, which are not mentioned in this Part of the Rules, as well as the scope of surveys of the equipment shall be agreed with the Register.

## 2 SCOPE OF COMMUNICATION EQUIPMENT

### 2.1 GENERAL REQUIREMENTS

**2.1.1** The equipment shall provide two-way communication between UUV and control station of the carrier ship in the surface and submerged positions.

**2.1.2** Communication with AUV in the surface position is provided by means of radio equipment and in submerged position — via sonar equipment.

**2.1.3** Communication between ROV and carrier ship in the surface and submerged positions is primarily provided via cable (as a rule, fiber-optic cable):

**.1** for ROV launched by means of the handling system, the information signals shall pass reliably through the optical channel adapters or slip rings of the rotary winch of the handling system;

**.2** for ROV used jointly with a tether management system (TMS), the information and control communication shall be provided not only by optical channel adapters or slip rings of the handling system winch, but also via optical channel adapters or slip rings of the TMS winch.

**2.1.4** Radio equipment in the surface position and sonar equipment in the submerged position may be used for receipt and transmission of signals to search for UUV or in an emergency.

## 2.2 LIST OF EQUIPMENT

**2.2.1** The list of communication equipment is determined by the UUV purpose requirements.

**2.2.2** The list of AUV communication equipment considering tasks of SCS may include following elements:

**.1** transmitting and receiving sonar antenna;

**.2** sonar antenna of bearing mode;

**.3** hardware located in the pressure hull.

**2.2.3** The ROV communication equipment includes cable and hardware located in the pressure hull.

**2.2.4** The unmanned underwater vehicles may be fitted with emergency sonar beacons to monitor the UUV position from the carrier ship in an emergency. The emergency sonar beacons are recommended for installation on unmanned underwater vehicles weighing more than 1000 kg. Herewith, an emergency receiver of sonar signals shall be installed on the carrier ship.

**2.2.5** As a means of emergency communication with the carrier ship in the surface position, the unmanned underwater vehicle shall be equipped with autonomous search radio complex.

## 2.3 SOURCES OF ELECTRICAL POWER SUPPLY FOR COMMUNICATION EQUIPMENT

**2.3.1** The communication equipment of unmanned underwater vehicles shall be powered from the main source of electrical power.

**2.3.2** The source of electrical power for operation of communication equipment of AUV is an accumulator battery.

**2.3.3** For ROV:

**.1** main source of electrical power is the source of electrical power of the carrier ship from which electrical power is supplied to ROV by cable.

For small or middle class observation ROV, an accumulator battery or another air-independent autonomous source of electrical power located directly on ROV is allowed to be used as a source of electrical power;

**.2** emergency source of electrical power is an accumulator battery or another air-independent autonomous source of electrical power.

**2.3.4** Emergency sonar beacon and autonomous search radio complex shall use only their own autonomous source of electrical power.

## 3 REQUIREMENTS FOR COMMUNICATION EQUIPMENT

### 3.1 AUV COMMUNICATION EQUIPMENT

**3.1.1** Communication equipment shall meet the UUV purpose requirements, including climatic ones, and shall be designed to provide ease and availability for inspection and maintenance.

**3.1.2** The communication equipment shall be designed taking into account integration with other systems and complexes.

**3.1.3** The communication equipment shall provide:

**.1** remote transmission of control commands between AUV and apparatus of sonar communications system on the AUV carrier ship;

**.2** transmission to a specified distance of telemetry information between AUV and apparatus of sonar communications system on the carrier ship;

**.3** transmission to a specified distance of AUV position to the apparatus of sonar communications system on the AUV carrier ship;

**.4** transmission to a specified distance of data on position coordinates of AUV in CS by means of bottom transponder beacons;

**.5** notification of an accident when the AUV is under ice when it is impossible to surface.

## 3.2 ROV COMMUNICATION EQUIPMENT

**3.2.1** Communication between the ROV and the carrier ship is conducted by means of a control cable (as a rule, fiber-optic cable) being a part of the communication tether cable connecting the carrier and the ROV.

**3.2.2** The equipment of cable communication between the ROV, TMS and control station shall provide:

**.1** transmission of control commands from the control console being a part of the control system (CS) and feedback data on fulfillment of commands by the equipment of the ROV and TMS;

**.2** monitoring of equipment condition and readings from sensors and devices of the ROV and TMS;

**.3** streaming of video from ROV and TMS cameras to the screens of the control stations with no loss in quality of image, while for ROV or TMS with several cameras the streaming video shall be transmitted simultaneously from at least two cameras.

**3.2.3** Communication lines and communication protocol shall provide the required rate of information exchange based on tasks undertaken.

**3.2.4** The redundant optic channel shall preferably be used for communication line.

## 3.3 COMMUNICATION EQUIPMENT DESIGNED FOR EMERGENCY USE

**3.3.1** For communication with the carrier ship, an autonomous search radio beacon shall be fitted on the unmanned underwater vehicle and shall provide:

**.1** automatic determination and periodical transmission to the carrier ship of geographical coordinates of the unmanned underwater vehicle in the GLONASS global navigation satellite system (GNSS) when the unmanned underwater vehicle is afloat. It is allowed to use the equipment capable of combining the measurements received from several GNSS: GLONASS, GPS, BeiDou, Galileo;

**.2** periodic transmission of geographic coordinates of the unmanned underwater vehicle to the carrier ship over a specified radio communication range via radio channel using the radio beacon module;

**.3** autonomous operation independent from ROV CS and power unit of the ROV;

**.4** time of autonomous operation of the search radio complex shall be at least 48 hours.

**3.3.2** The autonomous search radio beacon fitted on AUV is recommended to be integrated into the AUV control system to arrange the transmission of telemetry and service information via radio channel as well as the transmission of control commands.

**3.3.3** The emergency sonar beacon shall provide the communication with the carrier ship at a distance of at least twice the operating diving depth of the ROV.

**3.3.4** Communication in an emergency shall provide for the transmission of commands:

**.1** to release ballast for ROV surfacing;

**.2** to switch on/off the emergency sonar beacon;

**.3** to switch on/off the autonomous search radio complex;

**.4** to switch on/off the flashing beacon in the surface position.

## 4 LOCATION OF COMMUNICATION EQUIPMENT

### 4.1 LOCATION OF EQUIPMENT ON UUV

**4.1.1** Location of communication equipment is determined by the UUV purpose requirements.

**4.1.2** Means of control and indication of ROV communication equipment shall be located in the control stations of the carrier ship.

**4.1.3** The autonomous search radio complex of the unmanned underwater vehicle shall be located in the UUV upper part.

**4.1.4** The UUV emergency sonar beacon shall be installed in that part of the unmanned underwater vehicle which is submerged when the UUV is in surface or submerged position and considering accessibility for its maintenance and replacement.

**4.1.5** The equipment of onboard information-control and computation modules, connectors and cable lines of the unmanned underwater vehicles shall be as accessible as possible for visual examination and potential replacement.

# PART VIII. CONTROL SYSTEM

## 1 GENERAL

### 1.1 APPLICATION

The requirements of this Part apply to the UUV control system including its components.

## 1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of these Rules are given in in the General Regulations.

The following definitions are adopted in this Part of the Rules:

U U V c o n t r o l s y s t e m is a complex of elements (equipment and software) combined functionally to provide control of the motion, systems and technical means of the unmanned underwater vehicle during an intended mission and maintenance.

U U V s y s t e m e l e m e n t is a part of the system considered as a whole unit during the analysis.

## 1.3 SCOPE OF SUPERVISION

**1.3.1** Subject to supervision by the Register are elements being part of the control system (CS). As a rule, AUV CS consists of the following elements:

**.1** onboard program control system;

**.2** sensors and gauges for equipment functioning and environment parameters;

**.3** cable networks and switching equipment.

## 1.4 GENERAL REQUIREMENTS

**1.4.1** The control system shall monitor and control the technical means and systems of the unmanned underwater vehicle in all operating modes.

**1.4.2** CS equipment placed outside the watertight pressure-resistant structures of the unmanned underwater vehicle shall be IP68 (according to IEC 60529) rated for the maximum excessive pressure corresponding to the test diving depth.

**1.4.3** Structure of CS elements (components) shall provide for periodic verification of all measuring instruments being part of the system.

**1.4.4** As regards the electromagnetic compatibility, the CS shall meet the applicable requirements of Part XV "Automation" of the Rules for the Classification and Construction of Sea-Going Ships.

**1.4.5 Requirements for power supply.**

Power supply of the UUV CS may be provided from the energy supply system via feeding connectors.

Conversion of received electrical power into all types of power supply necessary for operation of CS elements shall be carried out by the units being part of the SC equipment.

**1.4.6** ROV shall be controlled by control commands transmitted via the cable from control consoles located on the carrier ship.

**1.4.7** UUV control system shall have embedded subsystems for self-diagnostics, operational checks and archiving of data on UUV operability as a whole.

# PART IX. BUOYANCY SUPPORT MATERIALS

## 1 GENERAL

### 1.1 APPLICATION

The requirements of this Part apply to materials that can be used for manufacture of buoyancy units of the unmanned underwater vehicles in order to provide UUV positive buoyancy when operating at working depths up to the maximum ones.

## 1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of these Rules are given in the General Regulations.

## 1.3 SCOPE OF SUPERVISION

Subject to supervision by the Register are the following products which provide positive buoyancy of the unmanned underwater vehicle:

buoyancy units;

materials used for buoyancy units.

## 1.4 GENERAL REQUIREMENTS

**1.4.1** Materials used for manufacture of buoyancy units shall comply with the purpose requirements, operating conditions and shall be approved by the Register.

**1.4.2** Change of buoyancy of materials applied for UUV buoyancy units under operating conditions shall comply with the specified requirements for UUV submerged duration on operating diving depth.

**1.4.3** Hydrostatic strength of the selected material for buoyancy units at single submersion shall not be less than 1,1 of the pressure value on the operating diving depth considering short-term fast sinkage to the design depth.

**1.4.4** Material of buoyancy units shall provide hydrostatic strength at specified UUV operating conditions in terms of the number of submersion cycles and specified time of being submerged at the diving depth.

**1.4.5** Materials for buoyancy units shall be capable of being machined or glued to get the required shape. The tear strength or shear strength after glueing shall not be less than the strength of solid material.

**1.4.6** Only special anti-erosion painting and other protective coating materials in accordance with technologies approved by the Register shall be applied for protective coating of buoyancy units made of syntactic foam.

**1.4.7** The material of buoyancy units shall have sufficient impact toughness considering possible collision with the sea bottom or artificial objects. If impact-resistant coating is applied on the buoyancy unit material surface, this coating shall be chemically compatible with this material and shall not cause alteration in the material integrity.

**1.4.8** When defining dimensions of buoyancy units, the possible deformation of adjacent hull structures (e.g. during submersion or recovery, exposure to excessive pressure, changes in temperature, etc.) shall be taken into account.

# PART X. EMERGENCY SURFACING AND RECOVERY SYSTEM

## 1 GENERAL

### 1.1 APPLICATION

The requirements of this Part apply to technical means of the unmanned underwater vehicles providing its emergency surfacing and recovery.

## 1.2 DEFINITIONS AND EXPLANATIONS

Definitions and explanations relating to the general terminology of these Rules are given in the General Regulations.

## 1.3 SCOPE OF SUPERVISION

Subject to the Register supervision are technical means of the unmanned underwater vehicles providing necessary actions in emergency situations (emergency UUV operation modes).

## 1.4 GENERAL REQUIREMENTS

**1.4.1** The UUV design shall provide means and action programs for operation of the technical means of the vehicle in accidents. The means and programs shall provide termination of activity in the event of malfunctions and for surfacing (recovery) of the unmanned underwater vehicle.

**1.4.2** In order to avoid full loss of the unmanned underwater vehicle, for example, in case of full loss of power supply, the installation of an energy-independent emergency surfacing system is recommended. Removable ballast with breakaway fasteners or pneumatic surfacing systems may be used.

**1.4.3** The ROV shall include a removable ballast set. The removable ballast shall be applied for adjustment of the ROV buoyancy in water of varying density. The emergency system shall provide the possibility to release the ballast in order to ensure the emergency surfacing.

**1.4.4** To supply electrical power to the emergency system, it is necessary to provide an emergency power source that will supply the following facilities and programs for a specified time:

emergency processor for activation of accident-prevention measures;

implementation of UUV recovery measures, for example, controlled surfacing, release and operation of emergency signal means;

ballast emergency release devices;

sending of emergency radio signal;

operation of emergency flashing beacon and, where necessary, means for transmission of acoustic emergency signal.

# PART XI. HANDLING SYSTEMS

## 1 GENERAL

### 1.1 APPLICATION

**1.1.1** The requirements of this Part apply to the handling systems of the unmanned underwater vehicles intended for launching a UUV or ROV with a tether management system (TMS) from the carrier ship to the water surface or to the required depth, for towing (in case of towed unmanned underwater vehicles), for lifting aboard the carrier ship as well as for emergency lifting aboard the carrier ship.

**1.1.2** This Part of the Rules supplements the Rules for the Cargo Handling Gear of Sea-Going Ships. All the requirements of the Rules for the Cargo Handling Gear of Sea-Going Ships apply to the handling systems, unless other requirements are specified in these Rules.

**1.1.3** For the purpose of this Part of the Rules, the following definitions have been adopted.

Safe working load of handling system means the greatest allowable mass of the unmanned underwater vehicle to be lifted out of water with its regular outfit, with allowance made for instantaneous values of the mass of water remained in permeable parts.

Design sea state means the sea state increased by 1 as against the design one.

Tracking means hoisting of the unmanned underwater vehicle from the water surface aboard the carrier ship in a seaway by means of the handling system equipped with a device for tracking the unmanned underwater vehicle during its movement in the seaway.

## 1.2 SCOPE OF SURVEYS

**1.2.1** Scope of surveys of UUV handling systems is determined by the requirements of 1.3 of the Rules for the Handling Gear of Sea-Going Ships. The following items are also subject to the Register survey:

**.1** counterbalance platforms (for tightening the guide wire ropes);

**.2** anti-sway appliances (during the transfer of the unmanned underwater vehicle upon emergence from water and until boarding on the carrier ship deck);

**.3** handling system trolleys;

**.4** dynamic load dampers in the carrying and guide wire rope systems;

**.5** release and clamping devices for UUV or TMS;

**.6** winches, reels, electrical and hydraulic drives.

## 2 GENERAL TECHNICAL REQUIREMENTS

**2.1** The handling system shall perform the following operations:

**.1** launching-recovery of UUV or ROV with TMS;

**.2** recovery aboard of UUV or ROV with TMS;

**.3** holding of UUV or ROV with TMS;

**.4** transmission of information flows between central control station (CCS) and ROV or between CCS, TMS and ROV via cables of the carrier ship, winches of the handling system and TMS, communication tether cable and umbilical and vice versa by means of data and control signal pick-ups (an optical communication channel is preferable or another data transmission channel);

**.5** transmission of electrical power from electric networks of the carrier to the communication tether cable and further to the ROV or to the TMS, the umbilical and to the ROV by means of rotating slip rings.

**2.2** The handling system may be of side, stern and moon pool type. Application of other than specified types of handling systems require submission of technical background confirming equivalent level of safety of the handling system.

**2.3** The handling system shall provide safe execution of its functions at sea state up to 5 inclusive.

**2.4** The control of UUV launching under normal conditions shall be effected by means of the winch drive.

**2.5** In order to avoid dangerous sway of the unmanned underwater vehicle and striking against the carrier ship side in a seaway, the handling system shall have a device approved by the Register to restrict swaying of the unmanned underwater vehicle from the moment of emergence until boarding on the carrier ship deck.

**2.6** The area of launching/recovery of the unmanned underwater vehicle including the overboard area surface in way of launching (recovery) area and the handling system control station shall have stationary lighting supplied from the main and emergency power sources.

**2.7** For safe servicing of the handling system, ladders or platforms providing easy access to the machinery, as well as guard rails (if required) shall be arranged. Where luffing trusses are used, the ladders and platforms shall ensure operation in any position of the trusses.

**2.8** For lifting and lowering the unmanned underwater vehicle, the handling system shall ensure launching and recovery operations at the carrier ship's static list of not less than 10° to either side and at static trim of 5°.

**2.9** The handling system control cabins or consoles installed on the upper deck shall be equipped with screen wipers or other effective facilities.

**2.10** Handling systems of the unmanned underwater vehicle shall have two independent power sources. Two independent pump stations shall be provided for hydraulic drives of handling system. Power sources together with power supply lines and distributor gear shall be designed so that failure of one system does not result in failure of the other.

**2.11** Handling system shall operate smoothly when the cargo winch is switched on/off. The handling system of the unmanned underwater vehicles shall ensure their installation on the deck or a mating device without impacts.

**2.12** The safe working load of the handling system as well as pull of the winch, diameter and breadth of the drum and their strength features shall be selected considering maximum mass of the unmanned underwater vehicle (with suspended modules of ROV, additional equipment and tools fitted), TMS weight, weight of the communication tether cable payed out from the winch of the handling system, additional cargo, entrained mass of water and dynamic loads that occur during launching and recovery of the UUV.

**2.13** The winch of the handling system shall be equipped with necessary current collectors, optical channel adapters (at least 4), cable and fiber-optic entries, braking and drum-blocking system in case of winch drive failure, speed adjustment, cable-laying device, indicator for payed out cable length, pipelines, cables and hoses, control and signal devices.

**2.14** The damper of the handling system shall be equipped with a device for gripping the UUV or TMS when the TMS-ROV pair is hung overboard (over stern, in the opening). This device shall grip and rigidly hold the TMS and have the possibility to rotate the TMS-ROV pair relative to the vertical axis as well as correct the tilt angle of the TMS-ROV pair.

**2.15** The communication tether cable on the winch of the handling system shall have negative buoyancy, and shall be resistant to tear and fractures.

**2.16** The control console of the handling system shall provide control from the local station.

# 3 DESIGN STANDARDS

## 3.1 GENERAL REQUIREMENTS

Methods of calculating forces in the cargo handling gear components are not specified by the Rules, however, in specific cases, the Register may require the use of calculation procedures it has approved.

## 3.2 DESIGN LOADS AND STRESSES

**3.2.1** In determination of the design loads, the requirements of the Rules for the Cargo Handling Gear of Sea-Going Ships shall be taken as a guide, as far as it is reasonable and applicable to the handling system.

**3.2.2** In addition to the requirements of the Rules for the Cargo Handling Gears of Sea-Going Ships, the design loads acting on the handling system for unmanned underwater vehicles shall include the following:

**.1** payload including the maximum weight of the unmanned underwater vehicle in air and its devices with all the components, including the TMS. In such case, the load acts when lowering and lifting in air and lowering and lifting in water, together with maximum negative buoyancy of the communication tether cable at the maximum diving depth;

**.2** loads due to entrained masses of water, silty clay, etc.;

**.3** dead load of handling system's structures and equipment;

**.4** external loads which can appear during operation (loads resulting from motions of the ship, sea state, wind force, ice accumulation, etc. shall be taken into account as design assumptions corresponding to the designed conditions);

**.5** braking inertial forces of the machinery operating at maximum speed;

**.6** operational dynamic loads in the handling system at design sea state during start/stop, wire rope slacking followed by sharp tensioning, and hydrodynamic loads (dynamic loads include the loads resulting from acceleration in vertical, longitudinal and transverse directions, including permissible heel and trim).

**3.2.3** The calculations shall be based on the assumption that the engaging angle of the communication tether cable may deviate from perpendicular by 12° in any direction. The calculations shall indicate the maximum hoisting speed of the unmanned underwater vehicle which shall be agreed with the Register.

## 3.3 ALLOWABLE STRESSES, SAFETY AND STABILITY MARGINS

**3.3.1** The strength of metal structures, machinery and loose gear of the handling system shall be calculated for static and dynamic loads. Allowable stresses in the calculations shall be taken as follows:

**.1** *ReH* — for static load;

**.2** 0,8 *ReH* — for dynamic load

where *ReH* is the material yield stress.

The safety factor of the handling system for unmanned underwater vehicle shall be at least 1,5. Reduction of safety margins of handling system's components shall be substantiated by the relevant calculations and agreed with the Register.

**3.3.2** If the handling system is designed for operation with different vehicles, calculations shall be made for the vehicle having the greatest mass.

## 3.4 CALCULATION OF MACHINERY

**3.4.1** In calculating the handling system machinery, account shall be taken of the requirements in 3.2 and 3.3 of this Part of the Rules, as well as 1.5 and 2.2 of the Rules for the Cargo Handling Gear of Sea-Going Ships.

**3.4.2** Drives of winches of handling systems shall be calculated in such a way that the maximum torque equal to the maximum pull which is at least 1,5 times the nominal pull of the winch, can be reached during subsequent operation of at least 5 min. Hydraulic cylinders shall be also designed for the pull 1,5 times exceeding the nominal pull. The relevant confirmatory calculations shall be submitted.

## 4 METAL STRUCTURES

**4.1** General requirements for the metal structures of the handling system are specified depending on the type of structure in accordance with the provisions of Sections 4 — 7 of the Rules for the Cargo Handling Gear of Sea-Going Ships, having regard to the requirements of this Section.

**4.2** To reduce dynamic forces in wire ropes and metal structures when the handling system is in operation during the carrier ship motions (particularly when the UUV rises off the wave) and to gain the required safety margins as related to dynamic loads, efficient compensators shall be provided, if necessary.

**4.3** The design of retractable bridges and luffing trusses (girders) of the handling system and their drives shall:

**.1** eliminate spontaneous movement of trolleys or retractable telescopic trusses during motions;

**.2** secure the handling system in extreme positions (operational and luffed) by efficient stopping devices (ties, slings, stops);

**.3** provide stopping of a trolley or a truss in any position when the drive is stopped;

**.4** eliminate jamming when the truss moves on rails.

**4.4** Trolleys for the unmanned underwater vehicles and retractable trusses of the handling systems shall have appliances preventing them from derailment and guard boards preventing foreign objects from being entrapped under the rollers or wheels.

## 5 MACHINERY

### 5.1 GENERAL REQUIREMENTS

**5.1.1** In addition to the general requirements for machinery mentioned in Section 2, the requirements of this Section and applicable requirements of Part IX "Machinery" of the Rules for the Classification and Construction of Sea-Going Ships and 1.5 of the Rules for the Cargo Handling Gear of Sea-Going Ships shall be taken into account when designing the handling system.

**5.1.2** Design of the handling system's machinery shall provide for synchronous operation of handling devices which jointly ensure appropriate positions of UUV or ROV with TMS during launching and recovery or luffing of the handling system with the possibility of their separate activation. The driving arrangements of winches and reels shall provide for formation and change of slack in the communication tether cable.

**5.1.3** Reels for ropes and communication tether cables shall have slip devices or breakdown torque clutches, which operate at loads not in excess of elastic strain loads in communication tether cables.

**5.1.4** The handling system machinery shall provide smooth movement of UUV or ROV with TMS without any jerks or delays, at speeds required for their safe launching, recovery or towing.

**5.1.5** In well-grounded cases, the handling system may be manually operated; in such cases, manually driven winches shall have an automatic hoist brake consisting of a handle, a ratchet and a brake.

**5.1.6** The handling system luffing gear, winches, reels and load trolleys traveling gear with electric or electrohydraulic drive shall have closed-band automatic brakes with a safety factor of braking as related to the work load not less than 1,75 and duplicating manual brakes with a safety factor of braking not less than 1,25. Where two independent brakes are available, manual brakes are not required.

**5.1.7** Duplicating manual brakes shall have worm gear. The effort on the brake handle (flywheel) shall not exceed 80 N.

**5.1.8** The machinery brakes shall be of closed-band type and shall be automatically locked in the following cases:

**.1** upon actuation of safety devices and electrical protection;

**.2** upon disconnection of the drive by control systems;

**.3** when power supply is interrupted or when the pressure in the hydraulic system is lower than the permissible value.

**5.1.9** The brake pulleys shall be of steel. Use of cast iron for brake pulleys and levers is not allowed.

**5.1.10** The stops of the handling system shall be provided with buffers.

**5.1.11** The rope capacity of the winch drums of the handling system shall be sufficient for taking the whole length of the used wire rope or communication tether cable and for launching UUV or ROV and TMS to the water surface down to the test depth so that not less than four dead turns of wire rope or communication tether cable remain on the winch drum, apart from those under the clamp. In such case, the following requirements shall be complied with:

**.1** diameter of the drum shall be not less than 20 diameters of the wire rope or communication tether cable;

**.2** flanges of the drums shall extend not less than 1,5 wire rope diameters above the upper layer of the wire rope or communication tether cable.

**5.1.12** Winches shall comply with the following applicable requirements:

**.1** cargo winches of the handling system shall be provided with two independent (main and standby) brakes. Main winch brake shall actuate automatically when the winch load drops. Standby winch brake shall be capable of actuating in case of faults of the main winch brake. One of the winch brakes shall be power-independent and shall actuate when the main power source fails by directly effecting the winch drum of the handling system. All the winch brakes

shall be designed for holding the 100 % design load at the upper layer of the rope or communication tether cable on the drum;

**.2** strength of the mechanical brake of the handling system shall be sufficient to withstand the design load;

**.3** lowering of the unmanned underwater vehicle shall be controlled by power drives independent from the brakes;

**.4** nominal winch pull shall be provided at the nominal reeling speed up to the upper layer of the rope or communication tether cable on the drum;

**.5** when the rope is wound in several layers, smooth drums may be used. In such cases, the winch shall be provided with a rope-coiling trolley;

**.6** if the communication tether cable (AUV rope) is inclined more than 2° from the winch drum axis, a winding device for rope or communication tether cable (rope-coiling trolley) shall be provided.

**5.1.13** The handling system shall be fitted with a mechanical brake which shall activate automatically if the lifting motor stops. If the automatic brake fails, an auxiliary facility shall be provided to prevent the cargo from falling. It may be operated manually and shall have a simple design.

## 5.2 SAFETY DEVICES AND CONTROL DEVICES

**5.2.1** Handling systems shall be equipped with control systems and devices that ensure their reliable non-continuous operation with smooth acceleration and deceleration, as well as the operational control of the handling system's machinery from the unmanned underwater vehicle control stations (panels).

**5.2.2** Handling systems (except for manually driven systems) shall have limit switches for alarming and automatic stopping of the following gear in their extreme positions:

launching and recovery of derricks and load hooks;

truss (girder) luffing;

traveling of bridge-type trusses or load trolleys.

**5.2.3** Where piston-type hydraulic drives are installed in the gear for luffing trusses/girders at their transition to extreme positions, limit switches may be omitted.

**5.2.4** Winches and reels of UUV handling systems shall have counters of payed-out length of communication tether cable, whose indications shall be repeated at the control station.

**5.2.5** The control panels shall be equipped with interlocking devices to ensure that only combinations of commands that do not cause dangerous or unforeseen conditions can be executed at the same time.

**5.2.6** Control systems of handling systems shall have an emergency stop button.

**5.2.7** Remotely controllable control units shall be equipped with a system to changeover between remote and local manual control. In case of remote control failure, all started operations shall be automatically stopped.

**5.2.8** Control system of handling systems shall provide for synchronized operation of winches and piston-type hydraulic cylinders. In case of de-synchronized operation of the handling system's gears, they shall be emergency stopped and alarm to the handling system control stations (panels) shall be given.

# 6 INTERCHANGEABLE COMPONENTS, STEEL WIRE ROPES AND CHAINS

## 6.1 INTERCHANGEABLE COMPONENTS

Interchangeable components shall comply with the requirements of 9.3 and 11.2 of the Rules for the Cargo Handling Gear of Sea-Going Ships with regard to the requirements of this Section.

## 6.2 STEEL WIRE ROPES AND COMMUNICATION TETHER CABLES

**6.2.1** Steel wire ropes shall comply with the requirements of 9.5 of the Rules for the Cargo Handling Gear of Sea-Going Ships with regard to the provisions of this Section.

**6.2.2** Handling ropes shall be made of galvanized steel wire, with a diameter of the wire in external strands of not less than 0,6 mm.

**6.2.3** Wire ropes used for the handling system shall be of rotation-resistant type.

**6.2.4** The standards for the wire ropes shall be agreed with the Register.

**6.2.5** Each wire rope and communication tether cable of the handling system shall be tested for the breaking strength as a whole.

**6.2.6** If the unmanned underwater vehicle is suspended by two ropes and one of them shall be replaced, the other one shall be replaced too.

**6.2.7** Steel wire ropes and communication tether cables shall be calculated for strength using formula

$$P/S \geq K,$$

where $P$ = breaking strength of the wire rope (communication tether cable) as a whole (specified in the Register certificate);
$S$ = maximum tension in the wire rope (communication tether cable) branch under a load equal to the safe working load of the handling system;
$K$ = safety factor of the wire rope (communication tether cable) as related to breaking strength, assumed equal to 6.

**6.2.8** The highest tension in the rope branch under a load equal to the safe working load of the handling system shall be determined by formula

$$S = Q / n\,\eta,$$

where $Q$ = the allowable working load corresponding to the safe working load of the handling system, in N;
$n$ = the number of rope branches;
$\eta$ = the efficiency of blocks.

**6.2.9** Steel wire rope shall be well lubricated throughout its length; the lubricant shall penetrate the rope and remain inside.

# PART XII. MATERIALS AND WELDING

## 1 MATERIALS

Materials used in manufacturing of unmanned underwater vehicles shall comply with the requirements of Part XIII "Materials" of the Rules for the Classification and Construction of Sea-Going Ships.

Materials shall be delivered with the Register Certificates in accordance with the Nomenclature of items of the technical supervision (Appendix 1 to 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).

## 2 WELDING

**2.1** Welding of components of the unmanned underwater vehicles and their parts is covered by the requirements of Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.2** Welding consumables for manufacture of framed load-bearing structures shall comply with the requirements of Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.3** The total scope of weld testing is determined by provisions of Section 3, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

**2.4** Welding of UUV structures and products subject to the Register technical supervision shall be performed by welders who have passed relevant testing and have been admitted by the Register to carry out welding according to the applicable welding procedures in accordance with the provisions of Section 5, Part XIV "Welding" of the Rules for the Classification and Construction of Sea-Going Ships.

Russian Maritime Register of Shipping

**Rules for the Classification and Construction of Unmanned Underwater Vehicles**

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