TÜRK LOYDU

RULES FOR THE CLASSIFICATION OF NAVAL SHIPS

Chapter 112 – Remotely Operated Underwater Vehicles

January 2022

This latest edition incorporates all rule changes. The latest revisions are shown with a vertical line. The section title is framed if the section is revised completely. Changes after the publication of the rule are written in red colour.

Unless otherwise specified, these Rules apply to ships for which the date of contract for construction as defined in TL- PR 29 is on or after 1st of January 2022. New rules or amendments entering into force after the date of contract for construction are to be applied if required by those rules. See Rule Change Notices on TL website for details.

"General Conditions" of the respective latest edition will be applicable (see Rules for Classification and Surveys).

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Chapter 112 – Remotely Operated Underwater Vehicles

SECTION 1

CERTIFICATION

A. General

1. Remotely operated vehicles (ROVs) built and tested according to the Rules and under survey of TL are eligible for Certification by TL.

2. ROVs built in accordance with other approved rules and tested under survey of TL are also eligible for Certification by TL.

3. Application for Certification of a ROV is to be made in writing to TL by the manufacturer or operator.

4. Documents relating to ROV are generally to be submitted in triplicate for examination. The scope of the documentation to be submitted depends on the type and equipment of the ROV in conformity with Section 2, C.

5. In the case of ROVs which are not built according to the Rules of TL, the application for Certification must be accompanied by the rules applicable.

6. The Surveyor is to be notified in due time of tests to be performed under survey of TL.

7. The Certificate is issued by TL after completion and successful testing of the ROV.

8. The Certificate testifies to the technical condition of the ROV at the time of the tests and acceptances by TL. It also confirms that the certified ROV conforms to current technological practice and that operation of the ROV is not subject to any objections on grounds of safety technology.

9. A TL Certificate normally remains valid for five years. However, the Certificate lapses if major modifications or repairs are carried out on the ROV, or if it has suffered substantial damage, without TL being notified accordingly.

10. ROVs which are to be certified for a period longer than five years are to undergo periodical surveys by TL, or can be classified and then subjected to periodical surveys by TL in accordance with the duration of class.

The nature and scope of the periodical surveys are to be agreed with TL in each individual case.

11. ROVs built in series can also be type-tested and certified accordingly. The nature and scope of the type-tests and of the supplementary monitoring of series production are to be agreed with TL in each individual case.

B. Surveys

1. Surveys to be performed in the course of the constructional and acceptance tests on the ROV are performed by TL in accordance with the following Rules in agreement with the manufacturer or operator.

2. Surveys required by the Naval Authority, international conventions or other arrangements are performed by TL on application or commission as required by the relevant provisions.

3. If a ROV has suffered substantial damage which impairs or nullifies the validity of the Certificate, TL will on application carry out damage and repair surveys and confirm the Certificate after the necessary repair measures have been performed.

SECTION 2

GENERAL CONSTRUCTIONAL REQUIREMENTS for REMOTELY OPERATED VEHICLES

A. Scope

1. The following requirements apply to the construction of unmanned ROVs which are to be certified by TL, including their control and monitoring devices and the means necessary for launching and recovering the ROV.

2. The Rules of construction, taken as a whole, encompass the range of systems and equipment for large working ROVs.

For smaller ROVs and for such as contain only a portion of the systems and equipment described below, the Rules apply only to the extent warranted by the type and equipment of the ROV. The documents to be submitted and the tests to be performed are reduced accordingly.

3. Designs deviating from the Rules of constructions can be approved if they have been recognized as equivalent by TL.

4. For ROVs or part thereof, the development of which is based on novel principles and which have not yet been sufficiently proved in practical operation. TL, acting in agreement with the manufacturer, is entitled to demand the presentation of additional documents and the performance of special trials.

5. National regulations which exist apart from the TL Rules are unaffected.

B. Definitions

1. Clamping devices

Equipment for securing a ROV, e. g. to a structure.

2. Control station

Desk or console comprising all the important indicators, controls and monitors for the remote control of the vehicle.

3. Garage

Cage in which the ROV can be launched and recovered, e.g. from the surface vessel, and from which the ROV can travel under water to the work site.

4. Launching and recovery system

Gear for launching and recovering a ROV.

5. Maximum operating pressure

Pressure corresponding to the maximum operating depth (nominal diving depth).

6. Nominal diving depth

Maximum depth to which the design of the ROV enables it to be lowered any number of times. This depth is related to the maximum operating pressure.

7. Overall system

ROV including its control, launching, recovery, working and supply systems.

8. Positioning equipment

Devices for the automatic control of course and depth.

9. Pressure vessel

Vessel subjected to an internal or external working pressure of 1 bar or over.

10. Pressurized gas container

Container or bottle for the storage and transport of gases under pressure.

11. Remotely operated vehicle (ROV)

Unmanned vehicle capable of operating under water with remote control.

12. Supply ship/station

Surface vessel/station for the support and supply of surface-dependent remotely operated vehicles.

13. Supporting structure

Framework or structure in which the individual components of the ROV are jointly mounted.

14. Test diving depth

The test diving depth corresponds to the external pressure at which the ROV is pressure-tested on completion. The reference for the diving depth is the lower edge of the supporting structure.

15. Tether

Cable used for launching and recovering as well as for raising or lowering the ROV.

16. Umbilical

Link between the supply ship and the ROV which can contain monitoring, communications and power supply cables as well as the tether.

17. Water pressure

The pressure due to the depth of water at which a ROV is operating at any time

18. Working equipment/appliances

Equipment, e.g. manipulators and tools, which is mounted on the ROV and is intended for the performance of underwater operations.

C. Documents for Approval

1. General

1.1 Before the start of manufacture TL is to be supplied with plans of the overall system and drawings of all components requiring approval, wherever applicable. The scope of this documentation, which is to be submitted in triplicate, shall be as set out below.

1.2 The drawings must contain all the details necessary to verify the design and its loading. Wherever required, calculations for components and equipment descriptions are to be submitted.

1.3 After the submitted documents have been approved by TL, the design is required to conform to them. Any major modifications are subject to the consent of TL before they are put into effect.

2. Overall system

The following documents are to be submitted:

2.1 Description of the ROV with details of mode of operation, intended function and essential design data such as:

– nominal diving depth

– operating (sea state) limits for launching and recovery

– other operating limits related to ambient conditions, e. g. salt/fresh water or similar

– speed

– type of propulsion and manoeuvring equipment

– type of holding device

– nature and scope of working appliances and equipment

– weight of vehicle, working load and ballast

2.2 General drawing of the ROV with plans of constructional details and materials, manufacturing and test specifications.

2.3 Plans (block diagrams) of the overall system together with details of facilities intended for the supply or support of the ROV (e.g. the control station, launching and recovery gear, power supply, etc.).

2.4 Summary description of anti-corrosion measures.

2.5 Trials programme.

3. Supporting structure

Drawings are to be submitted showing the supporting structure and the hull with details of such fittings as trimming weights, diving cells, pressure vessels, buoyancy elements, stabilizing fins, propulsion units, umbilical connection, control box, searchlight, ramming fenders, streamlining fixtures, manipulators, holding devices, instrument mountings, etc.

4. Diving, control and trimming devices

Arrangement of the diving, control and trimming devices; structural analysis as proof of diving capacity.

5. Pressure vessels

Drawings are to be submitted of pressure vessels with all essential data and the details necessary for an assessment of the safety technology including materials, manufacturing and test specifications.

6. Piping systems

The following are to be submitted:

6.1 Schematic diagrams of all piping systems including details of:

– materials

– maximum working pressure/temperature

– dimensions (diameter, wall thickness)

– fluids carried

– types of valves, fittings and connections

– types of hoses and couplings

6.2 Description of pumps and their drives indicating the essential design and operating data.

6.3 List of liquid-filled components (e.g. pressure- equalized components) indicating the nature of the liquid (e.g. oil, water, alcohol).

7. Control systems for depth, trim and positive/ negative buoyancy

7.1 Description of the control systems for depth, trim and positive/negative buoyancy including the necessary diagrams and detail drawings.

7.2 Details of the quantity, type and characteristics of buoyancy and ballast units and their means of attachment to the supporting structure.

8. Propulsion and manoeuvring equipment

Drawings and descriptions of the propulsion and manoeuvring equipment are to be submitted giving details of:

– the mode of operation and control of the systems

– power requirements (type and quantity)

– method of transmission to the drive

– safety devices

9. Clamping and positioning devices

Drawings and descriptions of the clamping and positioning devices are to be submitted giving details of:

– mode of operation and control of the clamping device

– magnitude of the clamping power

– response to a power failure

– method of controlling the positioning device

10. Working appliances

The following are to be submitted:

Drawings and descriptions of the proposed working appliances with details of:

– function of the appliances

– mode of operation and power supply

– control and monitoring systems

– safety devices

– arrangement and attachment to the supporting structure

11. Electrical equipment

The following are to be submitted:

11.1 A general layout plan of the electrical equipment containing at least the following details:

– rated voltage of systems

– rated power/current of electrical consumers

– switchgear with settings of overcurrent/overload protective devices, and fuses with their current ratings

– cable types and cross-sections

11.2 Energy balance of power supply.

11.3 Drawings and descriptions of the electrical power supply system for the ROV and the surface facilities (overall system).

11.4 Switchgear and distribution-system diagrams with parts lists.

11.5 Full details of electric-motor drives with details of control, measurement and monitoring systems.

11.6 Details of electrical cable penetrations through the walls of pressure vessels.

11.7 Short-circuit calculation with details of the circuit-breakers and fuses used in main, emergency and distribution switchboards indicating the rated current and switching capacity.

11.8 Description of the umbilical structure, including details of the pay-out and guidance system and the attachment to the ROV.

12. Automation, navigation and locating equipment

The following are to be submitted:

Descriptions, layout diagrams and equipment inventories for the ROV control station (control and operating elements, movement and position indicators) including a description of the overall instrumentation arrangement for the ROV and the control station.

13. Fire and explosion protection

The following are to be submitted:

Description of the fire and explosion-protection measures for the ROV including all back-up systems for submersibles intended for use in or from areas subject to an explosion hazard.

14. Launching and recovery system

The following are to be submitted:

14.1 Description of system and operating conditions

14.2 Details of conditions for the mounting and connection of the equipment.

14.3 Constructional drawings of:

– launching equipment

– supporting structures for gear and winches

14.4 Detailed drawings of interchangeable parts and fittings or reference to the relevant standards.

14.5 Drawings of mechanical equipment, e. g. winches, drives, etc.

14.6 Circuit diagrams of the hydraulic/pneumatic system.

14.7 Control system and description of safety devices.

14.8 Details of ratings and type of protection of electrical devices.

14.9 Details of tethers.

15. Garage system

The following are to be submitted:

15.1 Drawings and descriptions of the garage system with details of operating conditions, function and equipment of the garage.

15.2 Description of the connections between the ROV and the garage and between the garage and the supply ship/stations.

D. Tests and Trials

1. General

1.1 ROVs and their back-up systems undergo constructional and acceptance tests at the manufacturer's works. Wherever applicable, all the tests and trials prescribed in the following are to be performed and documented.

1.2 For parts produced in series, the prescribed tests may be replaced by other tests agreed with TL if they are recognized by TL as being equivalent.

2. Overall system

On completion the ROV together with its necessary back-up systems, e. g. the control station, power supply and launching/recovery facilities, is to be subjected to a functional and acceptance test which shall include at least the following elements:

– assembly inspection (except where this has already been carried out during supervision of construction)

– verification of weight and buoyancy

– testing of all safety devices

– functional test of diving and trimming systems

– functional test of mechanical, electrical and optical equipment including the holding and working devices

– underwater trial run

– test of the launching/recovery equipment

– verification of all important measuring instruments

– high-voltage and insulation testing of electrical equipment

3. Supporting structure

A check is to be carried out on the pressure-equalization of those parts of the supporting structure which are not resistant to pressure (for pressure-proof parts see 4.3).

4. Pressure vessels

4.1 A hydraulic pressure test is to be performed before the vessels are insulated or painted. This shall not cause leakage or any permanent deformation of the walls.

4.2 The test pressure for vessels is generally equal to 1,5 times the maximum working pressure when the pressure is applied internally.

4.3 Vessels liable to be subjected to an external pressure corresponding to the maximum permissible operating depth of the ROV are to undergo an external pressure test. The test pressure must be equivalent to at least 1,3 times the nominal diving depth.

5. Piping, valves, fittings, hoses and umbilicals

5.1 Piping

After installation, all pipes are to be subjected to a pressure and tightness test at 1,5 times the design pressure.

5.2 Hose lines

5.2.1 Proof is to be submitted to TL of the bursting pressure of each type of hose line. For liquids, hose lines must be able to withstand at least 4 times and, for gases, at least 5 times the maximum working pressure.

5.2.2 Each hose line is to be subjected to a hydraulic pressure test at at least twice the maximum working pressure.

5.2.3 Where hose lines are subjected to an external pressure, proof is required that 1,5 times the difference between the internal and external pressures can be tolerated without failure.

5.2.4 Umbilicals are to undergo a tightness test in which all the hose lines are simultaneously subjected to their respective maximum working pressure and measurements are performed on the electrical lines to verify that the insulation values specified by the manufacturer are maintained at a test voltage ≥ 500 V. The effectiveness of the strain-relief device is also to be tested.

5.2.5 Where the tether forms an integral part of the umbilical, the mechanical properties are to be tested on the basis of the approved documents.

5.3 Pumps

On completion, pumps are to be subjected by the manufacturer to a tightness test at maximum working pressure and to a performance test. Suitable Certificates are to be issued in respect of these tests.

6. Controls for depth, trimming and positive/ negative buoyancy

6.1 Trimming, bilge and ballast systems are to undergo a functional test.

6.2 The diving tank venting system and control elements (where present) are to be subjected to a functional test.

7. Propulsion and manoeuvring equipment

Operation of the propulsion and manoeuvring equipment is to be verified in the course of the underwater trial run, see 2.

8. Clamping and positioning devices

Clamping and positioning devices are to undergo a functional test comprising at least the following elements:

– the specified clamping power of the clamping device

– the limits of power and movement of clamping devices and the alignment of the submersible

– simulated power failure

– maintenance of course and depth with automatic positioning

9. Working appliances

As a minimum requirement, working appliances are to be tested with regard to:

– capacity to fulfil their specified function

– control and monitoring

– operation of safety devices

– avoidance of dangers to divers and the submersible

10. Electrical equipment

10.1 Electrical machines and switchboards, including operating and control stations, and automation, alarm and safety equipment are to be tested at the manufacturer's works.

New types of automation equipment shall have been type tested by TL. The nature and scope of the type test will be determined by TL in each individual case on the basis of Guidelines for the Performance of Type Approvals, Test Requirements for Electrical/Electronic Equipment and Systems.

10.2 All electrical systems and equipment are to be inspected and tested prior to putting in commission the ROV.

10.3 The settings and thresholds of the electrical protective devices are to be checked, and in addition the ROV electrical systems are to be subjected to a high-voltage and insulation test at a test voltage ≥ 500 V.

10.4 After the connectors have been fitted, each manufactured length of power-supply cable is to be subjected to a pressure test at 1,3 times the maximum operating pressure.

11. Automation, navigation and locating equipment

11.1 Indicators and monitors are to be checked for ergonomic arrangement, accuracy of readings and limit settings.

11.2 Automatic monitoring systems are to be checked for faultless operation under service conditions.

12. Launching and recovery system

12.1 After installation on board, the launching and recovery system is to be subjected to a dynamic test (braking test) using a test load equivalent to 1,25 times the working load.

12.2 Lifting attachments on the ROV are to undergo a static test at twice the working load.

12.3 Safety devices are to be checked.

13. Garage

13.1 Launching and recovery of the garage together with the ROV is to be verified by a functional test.

13.2 Exit and entry of the ROV to and from the garage is to be tested under water (functional test of all the garage equipment).

13.3 The garage lifting attachment is to be tested at twice the working load.

E. Markings

1. All important valves, fittings, operating elements, indicators and alarms are to be provided with a permanent marking resistant to seawater.

2. All pressure vessels and pressurized gas containers are to be prominently and permanently marked with the following details:

– manufacturer or supplier

– maker's number

– year of manufacture

– maximum working pressure (bar)

– test pressure

– capacity (ℓ or m^3)

– empty weight (of pressurized gas containers)

– type test mark on type tested pressure vessels

SECTION 3

PRINCIPLES for DESIGN and CONSTRUCTION of REMOTELY OPERATED VEHICLES

A. General Principles

1. ROVs and their components are to be designed for the conditions in which the specification states that they are to be used. This includes attention to the storage and transport of the ROV on the deck of a suitable supply/mother ship.

2. ROVs are to be designed and constructed in such a way as to ensure safe operation and allow proper maintenance to be carried out.

3. ROVs are to be so equipped that the operator is able to determine its position and operating condition.

4. ROVs which operate with diver support are to be equipped with a TV unit for monitoring the work site and with an EMERGENCY STOP device which can be operated from the ROV control station.

5. Due care is to be taken to ensure that inadvertent movements cannot cause the ROV to destroy itself or equipment located at the work site or to become separated from its control and supply lines.

6. ROVs are to be so designed that they respond in a defined manner (e. g. by positive buoyancy) to a failure of the control and power supply system.

7. Measures are to be taken which as far as possible prevent the ROV from becoming trapped. Propellers are to be provided with suitable protective devices.

8. ROVs are to be so designed and constructed that their operation causes no inadmissible environmental pollution.

B. Ambient Conditions

1. General

The design, selection and arrangement of all machines, devices and equipment located on board ROVs shall, as a minimum requirement, be governed by the following ambient conditions. Other ambient conditions may be approved for ROVs which are used only in restricted areas.

2. Inclined positions

Faultless operation is to be guaranteed at inclinations of up to 22,5° (static and dynamic) relative to the mounted position in any direction. Transitory inclinations of up to 45° shall not give rise to any undesirable functional changes or damage, particularly to bearings and foundation of machines.

3. Water

The design of ROVs and components is generally to be based on seawater in the temperature range from – 2 °C to + 32 °C with a salinity of 35 ppm and a density of 1 028 kg/m^3. A ratio of 0,101 bar/m is to be used for converting diving depth to pressure.

4. Sea state

The launching and recovery system for ROVs is to be designed for a sea state defined by the Naval Authority, but at least with a significant wave height of 2 m. Allowance is to be made for accelerations of 2 g in the vertical direction and 1 g in both the transverse and longitudinal direction (g = 9,81 m/s^2).

5. Climatic conditions

The transport, maintenance, inspection and dry testing of ROVs on board the supply ship and the launching and recovery system for the ROV are to be based on salty air in the temperature range from – 10 °C to + 55 °C with a relative humidity of 100 %.

For the protected control rooms for ROVs installed on board supply/mother ships allowance is to be made for a relative humidity of 80 % at a reference temperature of 45 °C.

6. Explosion protection

ROVs intended for use in or from areas subject to an explosion hazard are to be provided with suitable explosion protection.

7. Other ambient conditions

Where appropriate, the design of the ROV should also take account of the ambient conditions occurring during possible transport by air, i.e. depression.

8. Vibrations and shaking

Machines shall not cause vibrations or shaking which impose inadmissible stresses on other machines, equipment or the ROV itself. The amplitudes and accelerations stated in the TL Rules, Chapter 104 – Propulsion Plants, Section 1, D. are to be observed.

C. Materials

1. Materials for ROVs and their equipment shall be so selected that the ROV can be safely operated throughout its planned life under the proposed ambient and service conditions.

2. Materials must be suitable for the proposed application and have been approved by TL.

3. The manufacture, processing and testing of materials must proceed in accordance with approved standards or to approved manufacturer's specifications which have been examined by TL.

4. Materials for solid buoyancy elements must be suitable for the proposed pressure and temperature ranges and must have a low water-absorption factor.

5. Tethers are to be manufactured and tested in accordance with an approved standard or the TL Rules, Chapter 2 – Materials.

6. To the extent that this is necessary to the operation of the ROV and adequate protection by other means is not possible, materials must be resistant to the effects of the ambient media. In addition, materials must be mutually compatible.

7. Suitable proof, e. g. a manufacturer's Certificate, is to be provided testifying to the characteristics of materials used for parts subject to approval.

D. Pressure Vessels

1. Pressure vessels and pressurized gas containers are subject to the requirements stated in the TL Rules, Chapter 107 – Ship Operation Installations and Auxiliary Systems, Section 16 or other approved codes of practice.

2. Acrylic plastic viewports are to be designed and manufactured in accordance with Annex B. The minimum wall thicknesses indicated in Tables B.2 and B.3 may be halved.

E. Supporting Structure, Garage Design

1. The frame and supporting structures of ROVs including the garages, where applicable, are to be designed and constructed in accordance with approved codes of practice.

2. Approved methods of calculation are to be applied to the design of the supporting structure components and the garage construction. The structures are to be dimensioned in such a way that at the anticipated loads the effective stress does not exceed 60 % of the yield strength.

3. The supporting structure of the ROV and the garage construction are to be so designed that unintentional trapping of the structure is as far as possible prevented.

4. The lifting attachment of the ROV is to be so designed and arranged that the ROV can be launched and recovered under the maximum permissible sea state conditions.

F. Piping, Valves, Fittings, Hoses and Umbilicals

1. Piping

1.1 Pipes are to be designed and installed according to approved standards.

1.2 Pipes which are liable to be subjected in service to pressures higher than the design pressure must be provided with a pressure-relief valve, safeguarding against dangerous blow offs.

2. Valves and fittings

2.1 Shutoff valves must conform to an approved standard. Valves with screw-down valve-caps or spindles are to be safeguarded against the unintentional loosening of the cap.

2.2 Hand-operated shutoff valves are to be closed by clockwise rotation. The closed and open positions of functionally important shutoff valves must be clearly indicated. If they have to be handled by divers in water they have to be constructed such that they can be easily operated by divers wearing diving gloves.

2.3 Hose fittings are to be made of corrosion-resistant material and are to be designed to prevent unintentional release.

3. Hose lines and umbilicals

3.1 Hose lines, including their connectors, must be demonstrably suitable for the proposed operating fluids, pressures and temperatures. Only types approved by TL should be used.

3.2 Hose lines for liquids and gases are to be so designed that the bursting pressure is equivalent to at least 4 and 5 times respectively the maximum working pressure.

3.3 Hoses are to be fastened to their connectors by non-detachable hose couplings.

3.4 Where hoses are fitted with wire-mesh inlays which are not resistant to corrosion, the mesh is to be protected from water.

3.5 Umbilical hose lines must be provided with strain-relief devices unless they are provided with tethers.

3.6 Umbilicals must be protected against abrasion and damage. Where protective sheathing is used, care is to be taken to ensure that internal pressure does not build up in the event of minor hose leakages. Metal inlays in the protective sheathing are to be avoided.

3.7 Electrical cables in the umbilical must meet the requirements of K.

G. Devices for Controlling and Adjusting Depth, Trim, Positive and Negative Buoyancy

1. ROVs are to be equipped with devices for controlling and adjusting the depth and positive and negative buoyancy. It is necessary to ensure that these devices are effective under all the specified conditions of heeling and trim.

2. Depending on the type of ROV, the following may be regarded as devices for controlling the depth, trim, positive and negative buoyancy:

– fixed or changeable ballast and trimming weights in combination with the tether or handling system

– solid buoyancy elements, e.g. of pressure-resistant foam

– floodable ballast and trimming tanks

– propeller drives

– dynamically acting depth-control planes (e.g. on towed submersibles)

3. The control devices must be capable of compensating for the expected differences in water density and of ensuring that the ROV attains a defined diving state.

4. Remotely operated devices for controlling depth, trim, positive and negative buoyancy must be capable of being operated from the ROV control console. In addition, the console shall in these cases provide a continuous indication of the depth of the ROV.

H. Propulsion and Manoeuvring Equipment

1. Propulsion equipment

1.1 With regard to their type, number, size and arrangement, propulsion devices shall be designed to meet the requirements arising from the proposed application of the ROV.

1.2 Externally located propulsion units shall be pressure-balanced or designed for the ROVs maximum diving pressure.

1.3 Propulsion plants of ROVs are to be designed for intermittent and continuous operation.

1.4 Where propulsion plants use internal combustion engines, the requirements shall in each case be agreed with TL.

1.5 Electric propulsion motors are to be designed in accordance with the requirements of K.

1.6 Shaft penetrations through the walls of pressure vessels are to be provided with a proven shaft seal designed for the maximum diving depth.

1.7 Propellers are to be so arranged that the danger of unintentionally trapping the ROV or fouling the umbilical or tether is largely eliminated.

1.8 Devices for controlling the speed and/or the direction of rotation are to be so designed that the propulsion motor can be stopped in the event of their failure.

1.9 The operating condition of the propulsion units (thrust and direction of thrust and/or speed and direction of rotation) must be displayed at the ROV control station.

2. Manoeuvring equipment

ROVs are to be fitted with suitable equipment giving the ROV the necessary manoeuvrability.

I. Clamping and Positioning Devices

1. Clamping devices are to be so designed and constructed that they can be set to a specified holding power. In addition, means are to be provided to enable the holding claw or similar mechanism to be released in case of a power failure.

2. Positioning devices are to be fitted with suitable siting/locating sensors. The controllability of the positioning devices must be geared to the function of the ROV.

J. Manipulators

1. Manipulators are to be mounted on the ROV in such a way that the danger of unintentionally trapping the ROV or fouling the umbilical or tether is largely eliminated.

2. Tools which can be changed by remote control are to be provided with means for preventing the entry of seawater into the supply system.

3. Tools capable of rotating through 360° are to be so designed that any power, supply or control connections cannot be twisted off.

K. Electrical Equipment

1. Principles

1.1 All electrical equipment is to be so designed and installed that it is operational and serviceable under the design conditions specified for the ROV.

1.2 Systems for which even a brief failure cannot be tolerated are to have battery support or an uninterruptable power supply.

1.3 Where batteries are used, the TL Regulations for battery systems are to be observed. Battery chargers must have a characteristic conforming to the battery manufacturer's recommendations.

2. Power supply

2.1 Principles

2.1.1 The supply to the control station for the ROV shall be ensured by two mutually independent circuits with changeover facility. Alternatively a direct supply may be routed from the emergency switchboard of the supply ship or the power-supply station. Where ROVs operate with diver support, electrical systems whose failure could endanger the divers are to be designed for high availability, e. g. with battery back-up.

2.1.2 Devices are to be provided enabling the ROV to be de-energized during launching and recovery.

2.1.3 Approved supply systems are:

– direct current and single-phase alternating current, with both conductors insulated from the hull of the submersible

– three-phase alternating current with the three conductors insulated from the hull of the submersible

Networks with an earthed neutral are not permitted.

2.1.4 The permissible voltage and frequency deviations stated in the TL Rules, Chapter 105 – Electrical Installations, Section 1, F. shall not be exceeded.

2.2 Main power supply

2.2.1 A power balance shall be prepared to prove that the rating of the main power supply is sufficient.

2.2.2 Appropriate diversity factors may be assumed for consumers which are intermittently connected.

2.2.3 A power margin is to be provided for transient peak loads (e.g. on motor start-up).

2.3 Emergency power supply

2.3.1 An emergency power supply is necessary in those cases where the endangerment of the ROV, its environment or its function due to a failure of the main power supply is inadmissible.

2.3.2 The emergency power supply is to be so designed that, if the main power supply fails, the ROV can be placed in a stationary operating condition which at no time presents a danger. From the stationary condition it must be possible either to recover the ROV safely or to continue its task after the main power supply has been restored.

3. Power distribution

3.1 Electrical distribution systems are to be so designed that a fault or failure in one circuit does not impair the operation of other circuits.

3.2 In normal operation the emergency power distribution system may be fed via an interconnector feeder from the main power distribution system.

3.3 The lengths of cable from storage batteries to the switchboard are to be kept as short as possible. These cables are to be laid separately to the corresponding circuit-breaker and are to be specially protected against mechanical damage.

3.4 In switchgear, measures are to be taken for the prevention of parasitic voltages. Safety-voltage circuits shall not be run in the same conductor bundle as higher-voltage circuits or in the same cable duct. Terminals for different voltage levels are to be arranged separately and marked accordingly.

4. Protective measures

4.1 Each circuit is to be protected against short-circuit and overload.

4.2 All consumer circuits are to be designed for all-pole switching.

4.3 Where ROVs operate with diver support, a continuous insulation-monitoring system is to be provided which actuates a visual and audible alarm at the ROV control station when the value drops below a minimum level.

Where the possibility of danger to humans cannot be ruled out, provision is to be made for the automatic disconnection of the circuit concerned.

4.4 ROVs with electrical equipment are to be provided with an earthing and equipotential system. All non-current-carrying metal parts are to be connected to this. Where earthing is not via the fastenings, protective conductors are to be fitted. Where protective conductors are used, the following points are to be observed:

– The protective conductor must take the form of an additional cable, and additional line or an additional core in the power cable. Cable sheaths or armouring shall not be used as protective conductors but are to be connected to the protective conductors.

– A conductor which carries current in normal operation shall not simultaneously be used as a protective conductor and shall not be connected jointly with the latter to the hull of the ROV.

– The cross-section of the protective conductor must be equivalent to at least half the cross-section of the main conductor. However, with cross-sections of up to 16 mm^2 the cross-section must be the same as that of the main conductor. With separately laid protective conductors the minimum cross-section is 4 mm2.

In the propulsion system, the rating of the protective conductors is to be based on the maximum possible short-circuit currents of the equipment concerned, the maximum disconnecting times of the available protective devices and a maximum temperature rise of the protective conductor of 90 °C.

– Machines and equipment mounted on insulated vibration dampers are to be earthed via mobile cables, lines or copper braids.

– Protective conductors must be connected to the hull of the ROV at points which can easily be checked.

– In an easily accessible position on the superstructure or on the hull of the ROV respectively a connection point in the form of a connecting plate with M 12 stud bolts is to be provided to which, e.g. on the supply ship, a protective conductor can be connected without the use of tools.

5. Electrical equipment

5.1 IP 44 type protection is stipulated as a minimum requirement for the electrical equipment in ROVs. IP 22 is sufficient for the devices incorporated in the ROV control station.

5.2 The housings of non-pressure-compensated electrical equipment for underwater use are to be designed for the test diving depth as a minimum requirement.

5.3 Umbilicals, underwater cables and lines must be impervious to transverse water penetration (i.e. no water shall penetrate the sheath) and are to be designed for the test diving depth as a minimum requirement.

5.4 Drum cables are to be so designed that mechanical forces are not transmitted via conductors and their insulation.

5.5 Penetrations and plug-and-socket connections are to be designed and tested in accordance with Chapter 111 – Submarines, Section 11, C.5.7.2.

5.6 Insulation classes A and E are not permissible for the windings of electrical machines.

L. Automation, Navigation and Locating Equipment

1. Design principles

1.1 General principles

1.1.1 All devices for automatically monitoring and controlling the operating parameters of a ROV are to be so designed and constructed that they function properly under the design and ambient conditions laid down for the vehicle.

1.1.2 Computer-aided operational control systems for navigating, monitoring and controlling the ROV are permissible.

Details of the scope and redundancy of the equipment and of the extent and nature of the tests are to be agreed with TL.

1.1.3 All monitoring and control devices are to be clearly inscribed and identified.

1.1.4 Indicating instruments and optical displays are to be designed and inscribed in such a way as to facilitate clear and rapid readings.

1.1.5 No fault or failure whatsoever in the automation system shall lead to an uncontrollable operating condition.

1.1.6 Automation equipment shall as far as possible be protected against incorrect operation.

1.1.7 Automation equipment must be capable of maintaining the operating parameters specified for the ROV.

1.1.8 All inadmissible deviations from the operating parameters must automatically actuate a visual and audible alarm at the ROV control station. The same applies to automatic changeovers in the supply system and to faults in the control and monitoring system.

1.1.9 In addition to electronic control and monitoring devices, independent safety devices must be provided which prevent a fault in a system from creating an unsafe or undesirable operating condition.

1.1.10 Automatically operating monitoring and control devices must be capable of being switched to manual operation at any time. Exceptions to this rule are to be agreed with TL.

1.1.11 The thresholds of automation devices are to be co-ordinated in such a way that, when a limit value is reached, an indicating signal is actuated followed by the response of the safety devices on the expiry of a specific warning period or on the further variation of the process variable at a preset speed.

1.1.12 The overall behaviour of the automation equipment must be compatible with the time constants of the devices and components in the system.

1.1.13 The criterion for the noise immunity of electronic systems is provided by the IEC report "Electromagnetic compatibility of electronic installation in ships" (publication 60533).

1.2 Construction

1.2.1 Electronic automation equipment shall comprise easily interchangeable modules using the plug-in system wherever possible. The modules should be largely standardized, and the number of module type should be kept small to reduce the spares inventory.

1.2.2 Plug-in cards must be clearly marked or coded as a safeguard against accidental confusion.

1.2.3 Measures must be taken to prevent condensation inside electronic equipment even when it is switched off.

1.2.4 Wherever possible, automation equipment should be operable without forced ventilation. The operation of any cooling system is to be monitored.

1.2.5 Components must be effectively fastened. The mechanical loading of wires and soldered connections by vibrations and shuddering is to be minimized.

1.2.6 The construction of systems and equipment should be simple and straightforward. Easy accessibility for measurements and repairs is desirable.

1.3 Circuitry

1.3.1 Signalling, monitoring and control devices for safety-related functions must be constructed on the fail-safe principle, i.e. defects such as short-circuits, earth faults and breaks cannot produce conditions endangering humans or equipment. This is to be based on the assumption of single faults.

The failure of one module, e. g. due to short-circuit, shall not result in damage to other modules.

1.3.2 In programmable controllers the electrical values of the sensors shall meet the safety requirements for control devices. This means primarily:

– H-level start-up, i.e. by energization via NO contacts

– L-level shutdown, i.e. by de-energization via NC contacts

The requirements stated in 1.3.1 are unaffected.

1.3.3 Control devices for safety functions, e. g. emergency-stop sensors, are to be independent of a programmable controller and are to act directly on the output device, e. g. stop solenoid valve. They are to be safeguarded against unintentional operation.

1.3.4 Programmable controllers should be non-interacting and in case of fault should not cause disturbances in program-independent safety interlocks and safety switching sequences for fixed subroutines.

1.3.5 Freely accessible potentiometers and other components provided for adjustment or working-point setting must be capable of being locked in the operating position.

1.3.6 Switchgear interfaces must be so designed that contact chatter has no adverse effects on the operation of the equipment.

1.3.7 Printed conductors forming part of circuits extending outside the enclosure containing the printed circuit boards must be conditionally short-circuit-proof, i.e. in the event of an external short-circuit only the protective devices provided may respond without destroying the printed conductors.

1.3.8 The equipment shall not be damaged by brief voltage surges in the ship's power supply which may be caused by switching operations. The design shall allow for over-voltages amounting to approximately twice the rated voltage and lasting 1 ms.

Where equipment is supplied from static converters, allowance is to be made for periodic voltage pulses lasting about 0,5 ms. The amplitude depends on the type of converter and must be investigated in each case.

1.4 Power supply

1.4.1 Power supply units for automation equipment must at least have short-circuit and overload protection.

1.4.2 The reference-conductor system is to be so designed that breaks are as far as possible eliminated. This is achieved, for example, by the redundant design of exposed reference-conductor connections and links.

1.4.3 Automation equipment must be capable of reliable operation with the voltage and frequency deviations mentioned in the TL Rules, Chapter 105 – Electrical Installations, Section 1, F.

2. Instrumentation and control

2.1 For monitoring and controlling the ROV a control station or console is to be provided at which all the important data relating to the vehicle are displayed and all the controls and monitors, including TV and communications facilities, are located which are needed for the operation of the ROV.

2.2 The control station instruments for supervising, controlling and operating the ROV are to be grouped and arranged on ergonomic principles.

2.3 As far as feasible and rational, initiated control functions are to be indicated on the console or switchboards respectively.

3. Sensors

All devices for registering the ambient and operating conditions of ROVs shall have been type tested by TL.

4. Navigation and locating equipment

4.1 All the electronically operated navigation and locating equipment necessary to the safety of the ROV

is to be connected to the vehicle's emergency power supply. Its operational or stand-by status must be clearly indicated at the control station.

4.2 As far as is feasible and rational, ROVs should be equipped with an automatic emergency locating device (pinger).

4.3 The fitting of the vehicle with navigation and locating equipment shall comply with any official regulations applicable in the flag state.

M. Launching and Recovery System

1. The launching and recovery system must be capable of effecting the safe launching and recovery of the ROV under the ambient conditions mentioned in B. Where necessary, it is to be fitted with devices for reducing the dynamic loads.

2. Measures should be taken to prevent the ROV from bouncing against the hull of the ship or against the launching and recovery gear. In addition, devices are to be provided which prevent excessive twisting of the ROV during recovery.

3. The launching and recovering system is to be designed and constructed in accordance with approved technical practice for lifting gear. The mechanical equipment should conform to the TL Rules, Chapter 50, Lifting Appliances.

4. All interchangeable parts such as blocks, hooks, shackles, etc. must conform to approved standards and be designed for twice the working load.

5. The launching and recovery system is to be designed for a defined working load based on the weight of the ROV including its equipment and ballast weights.

Without more accurate evidence, seaway effects may be allowed for by increasing the relevant working load by 50 % for the purposes of calculation and dimensioning and assuming that it can act at an angle of 12° off vertical direction.

The permissible stresses in the components shall be as stated in TL Rules, Chapter 50, Lifting Appliances.

6. The maximum static tensile force on steel cables due to the working load shall not exceed 1/8 of the proved rupture strength. Where cables of natural or synthetic fibres are used, the maximum static force due to the working load
shall not exceed 1/10 of the proved rupture strength. Rupture strength is to be proved and certified by a tensile test to destruction.

N. Hydraulic Fluids, Lubricants, etc.

1. Media such as hydraulic fluids, lubricants, etc. are to be selected in accordance with the proposed ambient conditions. They shall not tend to congeal or evaporate over the whole temperature range.

2. Hydraulic fluids, lubricants, etc. are to be so selected that water penetration or contact with seawater does not seriously impair the serviceability of the ROV.

3. Hydraulic fluids, lubricants, etc. shall not contain toxic ingredients which are liable to be hazardous to health through skin contact or when given off in fumes.

4. Hydraulic fluids, lubricants, etc. shall not be corrosive or attach other operating equipment, e. g. seals, hose lines, etc.

O. Corrosion Protection

Remotely operated vehicles and all the associated components are to be effectively protected against corrosion.

ANNEX A

CALCULATION and DESIGN of PRESSURE HULLS UNDER EXTERNAL PRESSURE

See, Chapter 111, Submarines, Annex A.

ANNEX B

ACRYLIC PLASTIC WINDOWS

See, Chapter 111, Submarines, Annex B.

ANNEX C

DESIGN and MANUFACTURE of GLASS REINFORCED PLASTIC (GRP) CONSTRUCTIONS

See, Chapter 111, Submarines, Annex C.