

RULES FOR CLASSIFICATION

Underwater technology

Edition December 2015

Part 5 Types of UWT systems

Chapter 7 Remotely operated vehicles

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FOREWORD

DNV GL rules for classification contain procedural and technical requirements related to obtaining and retaining a class certificate. The rules represent all requirements adopted by the Society as basis for classification.

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CURRENT – CHANGES

This is a new document.

The rules enter into force 1 July 2016.

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SECTION 1 GENERAL

1 Introduction

1.1 Scope

1.1.1 These rules are valid for the construction of remotely operated vehicles (ROV) which shall be classified by the Society, including their operating and monitoring systems.

Unmanned underwater vehicles (UUV) may be (ROV) or autonomous underwater vehicles (AUV).

1.1.2 Remotely Operated Vehicles (ROV)

For the purpose of these rules unmanned underwater vehicles, which are during the mission physically connected with an umbilical to the relevant support vessel and which are controlled from there, are regarded as remotely operated vehicles (ROV). As an exception also wireless remote control is possible.

1.1.3 For further definitions, see [Sec.2 \[3\]](#).

1.2 Application

The requirements in this chapter shall be regarded as supplementary to those given in [Pt.2](#), [Pt.3](#) and [Pt.4](#).

SECTION 2 PRINCIPLES FOR CONSTRUCTION OF REMOTELY OPERATED VEHICLES

1 General

1.1

Wherever expedient and feasible, ROVs shall be designed and constructed in such a way that failure of any single component cannot give rise to a dangerous situation.

1.2

ROVs and their components shall be designed to meet the service conditions stated in the specification.

1.3

ROVs shall be designed and built to ensure safe operation and facilitate proper maintenance and the necessary surveys.

1.4

ROVs shall be designed and constructed in such a way that sufficient possibilities for monitoring during dived travels are given. This can be achieved, e.g., by video systems and acoustic instruments.

1.5

ROVs shall be so equipped that the operator can be informed about the position and the operating condition of the vehicle.

1.6

ROVs which operate with diver support shall be equipped with a TV unit for monitoring the work site and with special protection arrangements, which can be actuated from the control stand for the ROV.

1.7

Due care shall be taken to ensure that inadvertent movements cannot cause the remotely operated vehicle to destroy itself or equipment located at the work site or to become separated from its control and supply lines (e.g., by cable protector).

1.8

ROVs shall be so designed and constructed, that they achieve also a definite condition (e.g., positive buoyancy) even if the control and the energy supply fail.

1.9

Measures shall be taken to avoid that the ROV gets caught. Propellers shall be provided with adequate protection arrangements.

1.10

All possible stability cases of the ROV with minimum and maximum payload (NL) including all extension components shall be considered in surfaced and submerged condition.

1.11

The centre of gravity shall be located below the centre of buoyancy.

1.12

ROVs shall be so designed, that their operation causes no inadmissible environmental loads and endangering of the environment will be avoided as far as possible

1.13

If a special designed launcher for the ROV is provided, it shall be considered as part of the total ROV system and to be classed together with it, see [Sec.7](#).

2 Relation to other codes and standards

2.1

2.1.1 National codes and regulations concerning remotely operated vehicles existing alongside the Society's rules are unaffected.

3 Definitions

3.1 General Definitions

For general definitions see [Pt.1 Ch.1](#).

3.2 Main dimensions and main parameters

All dimensions are related to fix installed equipment in drawn-in/turned-in condition.

Table 1 Main dimensions and main parameters for ROVs

<i>Terms</i>	<i>Definitions</i>
<i>Co-ordinate system</i>	In relation to the ROV a fixed, right-handed co-ordinate system x, y, z according to Figure 1 is introduced. The origin of the system is defined by the aft perpendicular, the centre line and the basis line of the ROV. The x -axis points in longitudinal direction of the ROV positive forward, the y -axis positive to port and the z -axis positive upwards. Angular motions are considered positive in a clockwise direction about the three axes.

<i>Terms</i>	<i>Definitions</i>
<i>Length over all LOA</i>	The length LOA is the length between the most forward and most aft point of the ROV including fixed installed components of equipment, measured parallel to the x-axis [m].
<i>Total breadth (width) B</i>	The total breadth B is the maximum breadth of the ROV including all fixed installed parts of equipment, measured parallel to the y-axis [m].
<i>Radius of the pressure tight vessel R_m</i>	The radius R_m of a pressure tight vessel is the radius of the cylinder or the sphere related to the middle of the wall thickness [m].
<i>Total height H</i>	The total height H is the total height from baseline to upper edge of the vehicle including all permanently installed parts of equipment, measured parallel to the z-axis [m].
<i>Draught T</i>	The draught T in surfaced condition is the maximum vertical distance between the baseline and the water surface [m].
<i>Displacement</i>	The displacement of the surfaced ROV ready for surfaced operation is $\Delta\uparrow$, the displacement of the completely dived ROV is $\Delta\downarrow$ [t].
<i>Payload NL</i>	The maximum additional load for devices, equipment, materials, which are not necessary for the direct operation of the ROV, but are serving for work to be performed, investigation of the sea and scientific research is NL [kg].
Diving depths All diving depths are related to the baseline.	-
<i>Nominal diving depth NDD</i>	The nominal diving depth NDD is the diving depth for the unrestricted operation of the ROV [m].
<i>Test diving depth TDD</i>	The test diving depth TDD is the diving depth which is related to an external overpressure, to which the ROV is subjected to test conditions after completion or after essential repairs [m].
<i>Collapse diving depth CDD</i>	The collapse diving depth CDD is the diving depth decisive for the design of the pressure hull, where a collapse of the pressure hull shall be expected [m].
Velocities	
<i>Velocity $v_{0\uparrow}$</i>	The velocity $v_{0\uparrow}$ is the maximum operational speed of the surfaced submersible [kn] at a number of revolutions of the propeller(s) according to the maximum continuous propulsion power surfaced (MCR = maximum continuous rating).
<i>Velocity $v_{0\downarrow}$</i>	The velocity $v_{0\downarrow}$ is the maximum operational speed of the dived submersible [kn] at a number of revolutions of the propeller(s) according to the maximum continuous propulsion power dived (MCR).

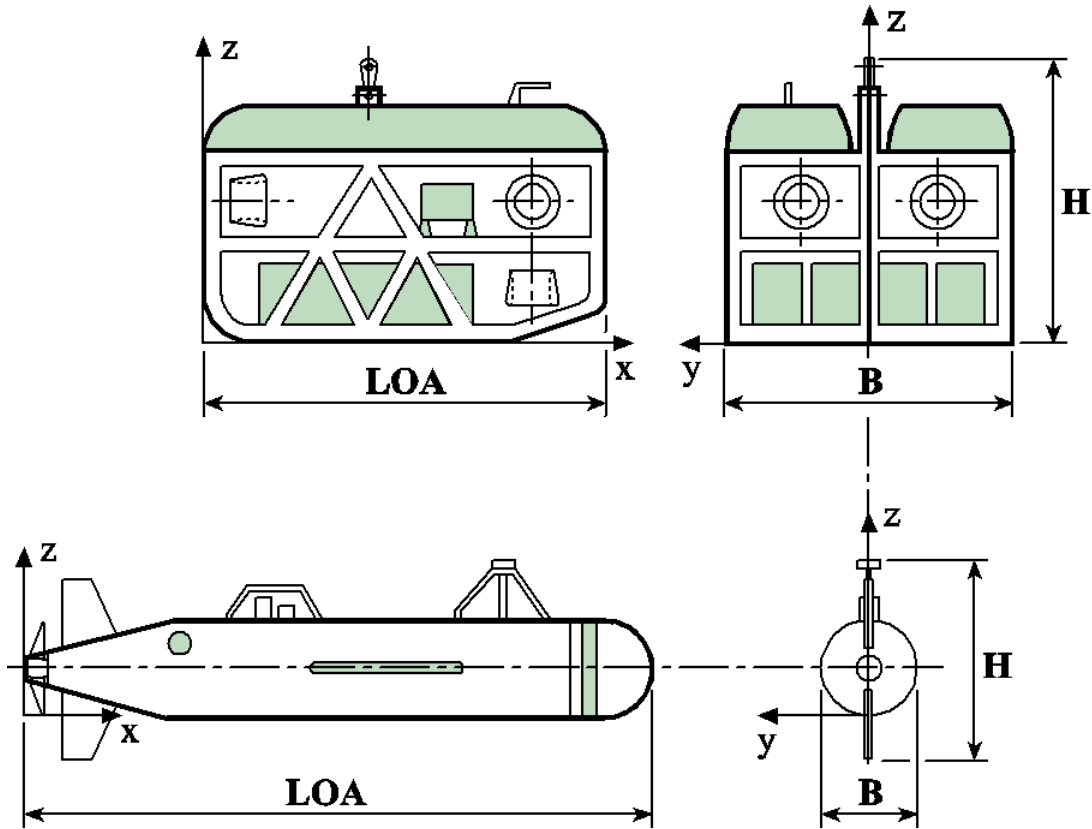


Figure 1 Fixed co-ordinate system and main dimensions for remotely operated (above) and autonomous underwater vehicles (below)

4 Certification Requirements

Products shall be certified as required by [Ch.6 Sec.2 Table 2](#).

Table 2 Certification requirements

<i>Object</i>	<i>Certificate type</i>	<i>Issued by</i>	<i>Certification standard*</i>	<i>Additional description</i>
Manufacturer	AoM	Society	e.g. ISO 9001	
Umbilical	VL	Society		For unique specimen type testing scope applies.
Pressure hull	VL	Society		
Structure/frame (load-bearing)	VL	Society		
Structure/frame (non load-bearing)	MC	Society		

<i>Object</i>	<i>Certificate type</i>	<i>Issued by</i>	<i>Certification standard*</i>	<i>Additional description</i>
Piping system	VL MC	Society Manufacturer		> DN 50 ≤ DN 50
Pressure vessel	VL	Society		
Hose line	MC	Manufacturer		
Electrical component and cable	MC	Manufacturer		
Electrical penetration	VL	Society		For unique specimen type testing scope applies.
Power supply	PC	Classification society		support vessel supply
Pressure supply	PC	Classification society		support vessel supply
Syntactic foam	VL	Society		
Control and automation Navigation and monitoring	MC	Manufacturer		Diving Pressure, suitability for application on seagoing ships
Working device	MC/VL	Manufacturer/ Society		Depending on type
*Unless otherwise specified the certification standard is the rules.				

5 Documentation Requirements

5.1 General requirements

5.1.1 Before the start of manufacture, documentation of the total system and drawings of all components subject to compulsory inspection, wherever applicable and to the extent specified below, shall be submitted in triplicate respectively in case of electronic transmission as single issue.

5.1.2 The documentation shall contain all the data necessary to check the design and loading of the system. Wherever necessary, calculations relating to components and descriptions of the system shall be submitted.

5.1.3 Once the documents submitted have been approved by the Society, they become binding for the execution. Any subsequent modifications require the Society's consent before they are implemented.

5.2 Documentation requirements

Documentation shall be submitted as required by Table 3.

Table 3 Documentation requirements for ROV

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Remotely operated vehicle	Z050 Design philosophy		FI
	Z060 Functional description	Description of the ROV with details of the mode of operation, proposed application including essential design data, like: <ul style="list-style-type: none"> – nominal diving depth – maximum operating time and maximum function time of identification signals – maximum range of a mission (radius) – diving procedure – operating limits for launching and recovery (seaway) – other operating limits in relation to environmental conditions (e.g. operating temperatures, fresh/salt water or geographical or current conditions) – speed below and eventually above water level as well as maximum towing speed – type of propulsion and manoeuvring equipment – type and extent of working devices and equipment – type of fixing system – weight of vehicle, pay load and ballast, displacement (submerged). 	AP
	Z010 General arrangement plan		AP
	M010 Material specification, metals		AP
	M030 Material specification, non-metallic materials		AP
	H130 Fabrication specification		FI
	Z120 Test procedure at manufacturer		AP
	Z140 Test procedure for quay and sea trial		AP
	P010 Flow diagram		AP
Z071 Failure mode and effect analysis	If required.	FI	

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
	M040 Coating specification		AP
	Z160 Operation manual	Including in detail the steps necessary for normal operation as well as for emergency operation in a clear and conceptual form and in the necessary sequence (e.g. as checklist). In addition the measures for the loading of the operating systems (e.g. batteries) shall be defined. In addition the planned lifetime and the permissible load and mission cycles of components of the equipment (e.g. acrylic windows, batteries, etc.) shall be defined herein.	AP
	Z180 Maintenance manual	Including all procedures for the preventive maintenance.	AP
	Z290 Record	Including documentation of all conditions relevant for operation (diving depth, mission time, damages, etc.).	FI
	Z120 Test procedure at manufacturer		AP
	Z140 Test procedure for quay and sea trial		AP
Equipment supporting structure	Z030 Arrangement plan	Including extensions like trimming weights, diving cells, pressure vessels, buoyancy elements, stabilizing fins, drives, umbilical connection, control box, search lights, ram protection, fairing, manipulators, fixing systems, instrument racks, etc.	AP
	H050 Structural drawing		AP
Exostructure	H050 Structural drawing		AP
Pressure containment	C030 Detailed drawing	Including drawings of the vessels and apparatus under external and internal pressure with all essential particulars and details necessary for appraising the safety of the equipment and including the specifications for materials, manufacture and testing.	AP
Diving, compensating and trimming system	S010 Piping diagram	Including of details for arrangement of diving, regulating and trimming systems with mathematical proof of the static diving capability.	AP
	S090 Specification of piping, valves, flanges, fittings		AP
	S130 Filling and discharge time calculation		AP

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Control and monitoring system	I020 Control system functional description	Including: <ul style="list-style-type: none"> – description of the system for depth, positive and negative buoyancy and trim including the necessary diagrams and component drawings – data concerning scope, type and design of buoyancy and ballast elements and their fixing on the supporting structure. 	AP
	I200 Control and monitoring system documentation		AP
Piping systems	S010 Piping diagram	Schematic diagrams including details of: <ul style="list-style-type: none"> – materials – maximum allowable working pressure – maximum allowable working temperature – dimensions (diameter, wall thickness) – media carried – type of valves and connections used and their operational parameter – type of hose lines. 	AP
	S041 Pneumatic control diagram		AP
	S042 Hydraulic control diagram		AP
	S050 Connections to the shell and to the sea chests		AP
Pump	Z100 Specification	Including description of pumps and their drives together with all important design and operating data.	FI
Umbilical	Z100 Specification	If applicable, including description of the design of the umbilical and its single elements, as well as the requirements for lifting cables.	AP
Components filled with liquids	Z100 Specification	Including definition of the type of liquid (e.g. oil, water, etc.).	FI
Propulsion and steering arrangements	C020 Assembly or arrangement drawing	Including descriptions of the propulsion and manoeuvring equipment with data about: <ul style="list-style-type: none"> – mode of operation and control of the systems – power consumption (type and quantity) – method of power transmission to propulsion units – safety systems. 	AP
Position keeping	N060 Manoeuvring booklet	The type and control of the positioning system shall be explained.	AP

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Underwater working device	Z030 Arrangement plan	For extension elements and working devices the effects on the total ROV system shall be defined.	AP
Underwater working device / fixing system	Z060 Functional description	Plans and descriptions including: <ul style="list-style-type: none"> – type and control of the fixing system – size of holding power – behaviour at energy failure – type of release system. 	AP
Electric system	E220 Electrical system philosophy	Including a general arrangement drawing containing at least the following information: <ul style="list-style-type: none"> – voltage rating of the systems – power or current ratings of electrical consumers – switchgear and safety devices (e.g. overcurrent relay) with indicating settings for short-circuit and overload protection; fuses with details of current ratings – cable types and cross-sections: 	AP
	E040 Electrical power consumption balance		AP
Electric power system, general	E230 Power supply arrangement		AP
Switchgear	E050 Single line diagrams/ consumer lists for switchboards		AP
Electric motor	E140 Assembly schedules and technical data	Including complete documentation for electric motor drives with details of control, measuring and monitoring systems.	AP
Battery	Doc type	Installation drawing including battery types.	AP
Cable penetrations	E110 Cable data sheet and design drawing	Including details of electrical penetrations through pressure vessel walls.	AP
Electric system	E200 Short circuit calculations	Including calculation of short-circuit conditions of all electrical components and distribution systems (e.g., power switches, power protection switches and fuses, indicating their current ratings and breaking capacity).	AP
	E090 Table of Ex-installation	For the operation in explosive endangered areas the required explosion classes shall be proven.	AP
Umbilical	E110 Cable data sheet and design drawing	Including electrical design and connection to ROV.	AP
Control and monitoring system/complete lay out	I090 Schematic description of input and output circuits	Including layout of the control stand.	AP

<i>Object</i>	<i>Documentation type</i>	<i>Additional description</i>	<i>Info</i>
Control and monitoring system/operating	I020 Control system functional description	Including description of the control and operating elements for the ROV and its equipment.	AP
Control and monitoring system/operating	I030 Block (topology) diagram		AP
Control and monitoring system/nautical and diving	N060 Manoeuvring booklet	Description of the nautical and diving instrumentation, including speed and position indicators.	AP
Control and monitoring system/safety and alarm	I110 List of controlled and monitored points	Including description of the safety and alarm systems.	AP
Control and monitoring system	I200 Control and monitoring system documentation	Including arrangement drawings/block diagrams of monitoring systems with lists of measuring points.	AP
Control and monitoring system/electronic components	I070 Instrument and equipment list	Including documentation for electronic components such as instrument amplifiers, computers and peripheral units.	AP
Control and monitoring system/data transfer	Z090 Equipment list	Including general diagrams and equipment lists for the data transfer systems and signalling equipment.	AP
Control and monitoring system/video system	T010 Functional description	Including general diagram and description of the video system.	AP
Control and monitoring system/positioning equipment	N040 Nautical workstation arrangement plan	Including descriptions, general diagrams and equipment lists.	AP
Fire and explosion protection	G040 Fire control plan	Including description of preventive fire and explosion protection measures for the ROVs which shall be used in or from explosion endangered areas.	AP
	G060 Structural fire protection drawing		AP
	G080 Hazardous area classification drawing		AP
Launcher/general	Z010 General arrangement plan	Including plans and descriptions of the launcher with data about operating conditions, task and equipment.	AP
Launcher/garage	Z030 Arrangement plan	Including plans and descriptions of the garage system, if applicable, and equipment of the garage.	AP
Launcher/connections	C060 Mechanical component documentation	Description of the connections between the support vessel and the launcher as well as between the launcher and the ROV.	AP
AP = For approval; FI = For information ACO = As carried out; L = Local handling; R = On request; TA = Covered by type approval; VS = Vessel specific			

For general requirements for documentation, including definition of the info codes, see [SHIP Pt.1 Ch.3 Sec.2](#). For a full definition of the documentation types, see [SHIP Pt.1 Ch.3 Sec.3](#).

6 Initial Test and trials

6.1 Total system

On completion, the ROV shall be subjected to a constructional, functional and acceptance test. This shall include at least the following individual tests:

- inspection of assembly (where not already performed during checking of manufacture)
- measurement of weight, buoyancy and stability
- testing of all safety devices
- functional testing of diving and trimming equipment
- functional testing of mechanical, electrical and optical equipment
- functional testing of working devices including the fixing system with regard to influence on the ROV
- trial trip submerged
- testing of launch and recovery procedures including functional test of the launcher
- verification of all essential measuring instruments
- insulation test and if necessary high voltage test and on the electrical equipment
- test of the control stand on the support vessel
- trials and functional tests under water with diving depths up to the nominal diving depth NDD

6.2 Supporting structure

6.2.1 It shall be checked, if the not pressure-proof parts of the supporting structure (hollow bodies, pipes, etc.) are pressure equalized. Pressure-proof components shall be tested according to [\[6.3.3\]](#).

6.2.2 The lifting points at the ROV shall be tested statically with 2.2 times the safe working load (SWL) (= weight and payload (NL) of the ROV).

6.2.3 The fixing point of the umbilical at the ROV shall be tested statically with 2.2 times the maximum permissible tension load of the umbilical.

6.2.4 Pressure vessels shall undergo a hydraulic pressure test before being insulated or painted. The test shall show no leakage or permanent deformation of the vessel walls.

6.2.5 The test pressure applied to vessels and apparatus with stress from internal pressure shall be equivalent to 1.5 times the maximum allowable working pressure (PB).

6.2.6 Vessels and apparatus which may be subjected to external overpressure according to the maximum allowable diving depth of the ROV shall undergo an external pressure test. The test pressure TDP shall be at least a multiple of the nominal diving pressure NDP according to [Pt.3 Ch.2 Sec.2 Table 2](#).

6.2.7 If the strength against pressure of vessels and apparatus cannot be sufficiently proven by calculation, an alternative verification shall be agreed with the Society.

6.2.8 All windows in pressure vessels shall be subjected to a hydraulic pressure test. The test may be performed after installation together with the pressure vessel or stand alone in a test device. The test pressure shall be determined according to [\[6.3.3\]](#). For the pressure test it shall be observed that the test pressure is not higher than 1.5 times the calculation pressure of the window.

6.3 Piping systems, umbilicals and pumps

6.3.1 Piping systems

- a) On completion but before being insulated or painted, all piping systems shall undergo a hydraulic pressure test at 1.5 times the maximum allowable working pressure.
- b) After installation, all piping systems shall undergo a tightness test at the maximum allowable working pressure. Pipes under diving pressure shall be checked in addition with test diving pressure (TDP) (inside or outside according to the actual load case).
- c) The safety systems shall be checked.

6.3.2 Pumps

On completion, pumps shall be subjected by the manufacturer to a pressure test at the maximum allowable working pressure, a tightness test as well as a performance test.

6.3.3 Umbilicals/supply lines

Umbilicals of remotely operated vehicles (ROV) shall meet special requirements. The required tests are divided in a type test of the prototype and a routine test of the final product.

All aspects for the tests and trials of umbilicals are defined in [Pt.4 Ch.5](#).

6.3.4 As far as the requirements in [\[6.4\]](#) are applicable for hose assemblies they shall be used.

6.4 Trimming, compensating and diving systems

The trimming, compensating and diving systems shall be subjected to a functional test.

6.5 Propulsion and manoeuvring equipment

The function of the propulsion and manoeuvring plant shall be proven at the occasion of trial travel under water.

6.6 Positioning system

The automatic keeping of a predefined position in breadth, length and depth shall be checked.

6.7 Working devices

6.7.1 See also [Ch.9 Sec.3](#).

6.7.2 The influence of the working devices on the total system shall be tested.

6.7.3 The working devices shall be checked at least with reference to:

- control and monitoring
- functioning of safety devices
- avoiding dangers for divers and the ROV.

6.7.4 The fixing systems shall be subjected to a function test where at least the following individual tests shall be performed with respect to:

- specified holding power of the fixing system
- limitations of power and distance travelled of the fixing systems as well as the directing of the vehicle
- simulation of an energy failure.

6.8 Electrical equipment

6.8.1 Electrical machines and automation, alarm and safety systems including steering and control stands shall be tested in the manufacturer's works.

The electrical systems shall be approved by the Society, preferably type approved components shall be used. Kind and scope of type tests shall be defined by the Society case by case.

6.8.2 All electrical systems and equipment shall be inspected and tested before the ROV is put into service.

6.8.3 The set points and response thresholds of electrical protective devices shall be checked.

Depending on the type of device the electrical equipment of the vehicle, if possible, shall be subjected to a high voltage test and an insulation test with a test voltage ≥ 500 V.

6.8.4 Electrical cables under external pressure shall be checked according to the electrical requirements for umbilicals defined in [6.4.3].

6.8.5 Electrical penetrations into vessels and apparatus under pressure and underwater plug connections shall be subjected to a type and routine test according to Pt.4 Ch.8 Sec.3.

6.8.6 All electrical equipment which is exposed to diving pressure shall be checked additionally for isolation after the first diving.

6.9 Automation, navigation and locating equipment

3.11.1 Indicating and monitoring systems shall be checked for the accuracy of their readings, their limit value settings and ergonomic arrangement according to the Society's document SHIP Pt.4 Ch.9.

6.9.1 Automation systems shall be checked for satisfactory performance under service conditions.

6.10 Launcher

6.10.1 The launching and recovery of the launcher including the ROV shall be checked in a functional test.

6.10.2 The lifting point of the launcher shall be tested with 2.2 times the safe working load. The device for harbouring the ROV to the launcher shall also be statically tested with 2.2 times the weight including payload NL of the ROV.

6.10.3 The entrance and the exit of the ROV to or from the launcher, respectively the garage if existing, shall be tested in dived condition and a functional test of all elements of the total system shall be performed.

SECTION 3 EQUIPMENT

1 General

For the intended operation purpose the ROV may be outfitted with different kind of equipment. Reference is given to [Pt.3 Ch.4](#).

2 WORKING DEVICES

Working devices are components or sub-systems, which are optionally mounted to the ROV. Working devices are e.g. tools, like manipulators or grabbers, or removable equipment frames (skids).

Only working devices shall be applied to ROVs provided that the influence on the total system is investigated and approved by the Society.

Working devices shall be arranged on the ROV that the risk of trapping is minimised and that the umbilical or the lifting cable becomes entangled.

Fixing systems shall be designed and constructed such that a defined holding power can be adjusted. In addition, devices such as the holding claw or similar shall be possible to open in case of energy failure.

Concerning all further requirements for working devices, respectively for their separate Certification, see [Ch.9](#).

3 Acrylic windows

If openings with acrylic windows are required in pressure-proof parts of the construction, e.g. for the application of search lights and cameras, the design and dimensioning of these windows shall be performed according to [Pt.4 Ch.7](#). In justified cases the minimum wall thickness can be reduced in agreement with the Society.

Viewing windows of other materials as acryl glass may be approved by the Society according to separate testing.

SECTION 4 MACHINERY SYSTEMS

1 General

The technical requirements for machinery systems like:

- propulsion and manoeuvring equipment
- ballasting
- control/compensating and trimming systems
- umbilicals
- piping systems
- pumps and compressors
- vessels and apparatus under pressure
- control and monitoring

are given in [Pt.4](#).

2 Piping systems and umbilicals

Piping systems include:

- pipe lines
- fittings
- hoses
- pumps and compressors.

2.1 General

2.1.1 Piping systems shall be designed and installed according to internationally recognized standards. For the selection of the material, manufacturing and computation the Society's document [SHIP Pt.4 Ch.6](#) can be applied, as far as applicable.

2.1.2 Piping systems shall be dimensioned for a design pressure (PR) equal to the maximum allowable working pressure (PB).

All piping systems which may be loaded with the diving pressure shall be designed additionally for 1.0 times the collapse diving pressure (CDP) (according to the load case from outside or inside).

2.2 Piping systems

2.2.1 Piping systems which may be exposed to pressures above the design pressure shall be provided with an overpressure protection which guarantees a safe blowing-off.

2.2.2 Piping systems for gases and electric cables shall be installed separately. Piping systems which are endangered to mechanical damage shall be protected.

2.3 Fittings

2.3.1 Shut-off devices shall conform to a recognized standard. Fittings with screw-down covers and spindles shall be safeguarded against accidental unscrewing.

2.3.2 Manual shut-off devices shall be closed by turning in the clockwise direction. The open and closed positions of essential shut-off valves shall be clearly recognizable. If they shall be operated by a diver under water they shall be so designed that the handling is possible while wearing mittens.

2.3.3 Fittings for hoses shall be made of corrosion resistant material and shall be so designed that unintentional loosening can be excluded.

2.4 Hose assemblies

As far as the requirements of [2.6] are relevant for hose assemblies, they shall be applied.

2.5 Pumps and compressors

The casing of pumps and compressors shall be provided pressure proof. The proof of strength shall be done by computation. If this is only possible in an insufficient way, these casings shall be tested according to the Society's requirement.

2.6 Umbilicals

Umbilicals as connecting element between support vessel/launcher and launcher/ROV may contain lifting cables and supply lines, like electrical supply, hydraulic and pneumatic supply as well as signalling and monitoring, within a joint encasing.

All aspects for the design of umbilicals are treated in Pt.4 Ch.5.

2.7 Compressed air systems

2.7.1 Compressed air systems which come in contact with seawater shall be designed adequately and be separated from other systems. In addition measures shall be taken to exclude the entrance of seawater in the compressed air system as far as possible.

2.7.2 Compressed air systems shall be equipped with pressure indicators. Maximum working pressures shall be marked.

2.8 Hydraulic systems

2.8.1 The pressure creating and distribution components of the hydraulic systems shall have adequate performance if the manoeuvring systems are hydraulically driven. In addition it shall be defined if and how much additional capacity for working devices to be connected (compare Pt.5 Ch.9) shall be made available.

2.8.2 If the hydraulic aggregate is located on the launcher, an adequate electrical feeding via the umbilical shall be provided. A supply with higher voltage and subsequent voltage transformation to a lower voltage is permissible.

2.8.3 Concerning selection of materials, manufacturing and computation the Societys document SHIP Pt.4 *Machinery and Systems* are valid.

3 Pressure vessels and apparatus under pressure

3.1 Pressure vessels and apparatus under outside pressure

The calculation procedure of Pt.3 Ch.3 Sec.4 or an internationally recognized standard shall be applied.

3.2 Pressure vessels and apparatus under internal pressure

For pressure vessels, gas cylinders and apparatus under internal pressure, the requirements defined in [SHIP Pt.4 Ch.7](#) or other recognized regulations according to state of the art (e.g., AD published rules) are valid.

4 Arrangements for control resp. adjustment of depth, trim, positive and negative buoyancy

Unmanned, remotely operated vehicles shall be provided with arrangements for control respectively adjustment of depth, positive and negative buoyancy. It shall be secured that these arrangements are effective under all specified conditions of heel and trim.

Depending on the type of ROV the following systems may be regarded as arrangements for control and support of depth, trim, positive and negative buoyancy:

- lifting cable if the ROV is connected tight with it
- releasable weights (for quick diving to a wanted depth resp. for emerging)
- fixed resp. adjustable ballast and trimming weights
- rigid buoyancy appliances, e.g. of pressure resistant foam
- floodable ballast and trim tanks
- propeller drives
- depth rudders with dynamic effects (e.g., for towed ROVs).

The control devices shall be capable of compensating the expected differences in water density and of ensuring that the submersible attains a defined diving state.

The ROV shall be stable in each operational phase and be in the position to return to the water surface.

The arrangements for control of depth, trim, positive and negative buoyancy shall be controlled from the control stand of the ROV on the support vessel. In addition the depth of the ROV shall be indicated continuously on the console.

5 Propulsion and manoeuvring equipment

5.1 Propulsion equipment

5.1.1 With regard to their type, number, size and arrangement, propulsion devices shall be designed to meet the requirements arising from the planned purpose and location of the mission.

5.1.2 Propulsion units shall be designed for the collapse diving pressure (CDP) or shall be pressure balanced.

5.1.3 Propulsion plants for ROVs shall be designed for intermittent and continuous operation.

5.1.4 Electric propulsion motors shall be designed in accordance with the requirements of [Sec.5](#).

5.1.5 Shaft penetrations and other penetrations through the wall of pressure vessels shall be provided with a proven seal designed for the collapse diving pressure (CDP).

5.1.6 Propellers shall be so arranged that an unintentional trapping of the ROV or getting caught in the umbilical or lifting cable can be largely excluded. For a joint mission with divers the propellers shall be protected against unintentional approach, e.g. by ducting and grids or nets before and aft.

5.1.7 Devices for controlling the speed and/or the direction of the rotation shall be so designed such that the propulsion motor can be stopped even in the event of their failure.

5.1.8 The operating condition of the propulsion units (direction of thrust and rotation) shall be displayed at the control stand on the support vessel.

5.2 Manoeuvring equipment

5.2.1 Remotely operated vehicles shall be equipped with suitable devices which provide the vehicle with the required manoeuvrability under consideration of the most unfavourable operating conditions. A propeller thrust for going backwards shall be provided which enables an effective braking of the vehicle.

5.2.2 Depth and side rudder devices shall be designed for the greatest loads which result at underwater journeys from the steering forces resp. at planned longer surface journeys from pitching movements and wash of the sea. The equivalent stress in the rudder shaft shall not exceed $0.5 \times$ yield strength.

5.2.3 Depth rudders shall be so designed that the wanted depth can be kept in the assigned speed range and under all load conditions.

5.2.4 For the swivelling devices of the propulsion units, which serve at the same time as manoeuvring device, the same requirements are valid as for rudders.

5.3 Mission on the bottom of the sea

5.3.1 If the movement is realised by wheels or crawlers, the foot print area shall be adjusted to the permissible bottom pressure in the planned mission area. Design and drive shall be agreed with the Society case by case.

5.3.2 At sandy or muddy sea bottom, propulsion units which are used for the advance shall not be positioned too low or shall be totally avoided as the visibility around the vehicle can be strongly limited due to the whirled up bottom material.

5.3.3 Systems for locating of obstacles, like rocks, wrecks, pipelines, offshore structures, etc. shall be provided to avoid collisions safely.

6 Positioning system

Dynamic positioning may be required for certain operational purposes For remotely controlled vehicles a cooperation with the support vessel may be required.

6.1 General

6.1.1 Dynamic positioning means that a vehicle keeps automatically its position at the water surface or in the underwater space (within accuracy of the system defined for the duty of the mission) or that it moves on a predefined track, using solely the effect of propulsors.

6.1.2 Systems for dynamic positioning shall include the following subsystems:

- as far as required for safe operation redundant source of energy with switchgear and energy distribution
- a number of drives/propulsors with motor and, if necessary, gear as well as propeller, eventually slewing gear; the control of the positioning system shall be adequate to the purpose of the mission of the ROV
- suitable sensors for determination of location/position
- control system including computer system with software, monitoring display at the control stand and reference system for the position
- Further details concerning the requirements for such systems are defined in [SHIP Pt.6 Ch.7](#).

6.2 Positioning systems of ROVs

For ROVs the use of dynamic positioning and the required equipment for this shall be agreed with the Society case by case.

SECTION 5 ELECTRICAL SYSTEMS

1 Principles

All electrical equipment shall be so designed and installed such that it is operational and serviceable under the design conditions specified for the remotely operated vehicle.

Systems for which even a brief failure cannot be tolerated, shall be provided with battery support or shall be supplied by an uninterruptible power.

Where batteries are used, the special operating conditions shall be observed. Battery chargers shall have a characteristic conforming to the battery manufacturer's recommendations.

2 Power supply

2.1 Principles

2.1.1 Devices shall be provided enabling the ROV to be voltage absent during launching and recovery.

2.1.2 Approved supply systems are:

- direct current and single phase alternating current, with both conductors insulated from the hull of the ROV
- three-phase alternating current with the three conductors insulated from the hull of the ROV; networks with an earthed neutral are not permitted.

2.1.3 The permissible voltage and frequency deviations stated in [SHIP Pt.4 Ch.8 Sec.2 \[1.2\]](#) 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 shall be provided for transient peak loads (e.g. on motor startup).

2.2.4 A subordinate mistake shall not hinder the distribution of sufficient power for the drive of the vehicle or other essential systems, like search lights and video cameras.

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 shall be so designed that, if the main power supply fails, the ROV can be brought in a stationary operating condition which at no time presents a danger. From this condition it shall be possible either to recover the vehicle safely or to continue its mission after the main power supply has been restored.

3 Power distribution

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

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

The lengths of cables from storage batteries to the switchboard/switching devices and end consumers shall be kept as short as possible. These cables shall be laid separately to the corresponding circuitbreaker and shall be specially protected against mechanical damage.

In switchgears, measures shall be taken for the prevention of parasitic voltages. Voltage circuits for safety extra low voltage shall not be run in the same conductor bundle or in the same cable duct as higher voltage circuits. Terminals for different voltage levels shall be arranged separately and marked accordingly.

4 Protective measures

Each circuit shall be protected against short circuit and overload.

All consumer circuits shall be designed for all-pole switching.

If remotely operated vehicles operate with diver support, electrical systems whose failure could endanger the divers, shall be designed for high availability, e.g., with battery back-up.

Where remotely operated vehicles operate with diver support, a continuous insulation-monitoring system shall 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 shall be made for the automatic disconnection of the circuit concerned.

An emergency stop device for the ROV shall be installed at the control stand. It shall be designed to exclude unintentional actuation.

Remotely operated vehicles with electrical equipment shall be provided with an earthing and equipotential system. All non-current-carrying metal parts shall be connected to this.

Where earthing is not provided via the fastenings, protective conductors shall be fitted.

Where protective conductors are used, the following shall be observed:

- a) The protective conductor shall take the form of an additional cable or additional line or an additional core in the power cable. The use of armouring as protective conductors shall be checked case by case and to be approved by the Society.
- b) 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 vehicle.
- c) The cross-section of the protective conductor shall be equivalent to at least half the cross-section of the phase conductors. However, with cross-sections of up to 16 mm² the cross-section shall be the same as that of the phase conductor. With separately laid protective conductors the minimum cross-section is 4 mm².
- d) The connections of the protective conductors shall be installed at locations which can be easily checked.
- e) In an easily accessible position on the structure of the ROV a connection point in the form of a connecting plate with preferably M 12 stud bolts shall be provided to which, a protective conductor can be connected without the use of tools. This connection serves for the compensation of the potential between the recovered ROV and the support vessel.
- f) Depending of the endangering potential of the electrical plant of the ROV a device for compensation of the potential shall be provided which is already effective during recovery out of the water.

5 Electrical equipment

The housings of non-pressure-compensated electrical equipment for underwater use shall be designed for the collapse diving pressure (CDP) as a minimum.

Penetrations in vessels and plug-and-socket connections shall be designed and tested in accordance with the Society's document [SHIP Pt.4 Ch.8 Sec.3](#) under consideration of [SHIP Pt.4 Ch.8 Sec.3 \[5.1\]](#).

For electrical equipment a minimum type of protection IP 44 is required.

Insulation class F shall be provided for the windings of electrical machines.

Underwater cables and lines shall be impervious to transverse water penetration (i.e. no water shall penetrate the sheath) and shall be designed for an overpressure which is equivalent to the collapse diving pressure (CDP). For further requirements concerning design and testing see [Pt.4 Ch.5](#).

Drum cables shall be so designed that mechanical forces are not transmitted via electrical components.

For monitoring the manoeuvres and activities of the ROV under water suitable searchlights and video cameras shall be provided.

SECTION 6 CONTROLS AND COMMUNICATION

1 Design principles

1.1 General principles

1.1.1 All devices for automatically monitoring and controlling the operating parameters of a ROV shall 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 the ROV are permissible. Details of the scope and redundancy of the equipment shall be agreed with the Society.

The systems shall be approved by the Society and type approved components shall be used.

The check contains the applied devices (hardware) as also the effectiveness of software programs belonging to them. Kind and scope of the check shall be agreed with the Society.

1.1.3 Computer aided operational control systems shall be capable of being switched to manual operation at any time. Exceptions to this rule shall be agreed with the Society.

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

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

1.1.6 Automation equipment shall be capable of maintaining the predefined operating parameters of the ROV.

1.1.7 All inadmissible deviations from the operating parameters shall automatically actuate a visual and audible alarm at the control station.

This applies additionally to automatic changeovers in the power supply system and to faults in the control and monitoring system.

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

1.1.9 The response settings of automation devices shall be coordinated 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 pre-set speed.

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

1.1.11 As criterion for the noise immunity of electronic systems the IEC standard 60533 (*Electromagnetic compatibility of electronic installation in ships*) shall be applied.

1.2 Construction

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

1.2.2 Plugin cards shall be clearly marked or coded as a safeguard against accidental confusion.

1.2.3 Measures shall be taken to prevent condensation inside electronic equipment even when it is switched off. A standby heating is recommended.

1.2.4 Wherever possible, automation equipment shall be preferably operable without forced ventilation. The functioning of any cooling system shall be monitored.

1.2.5 Components shall be effectively fastened. The mechanical loading of wires and soldered connections by vibrations and shaking shall be minimized.

1.2.6 The construction of systems and equipment shall 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 shall be constructed on the failsafe principle, i.e. defects such as short circuits, earth faults and breaks cannot produce conditions endangering humans or equipment. This shall 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:

- Hlevel startup, i.e., by powering via NO contacts
- Llevel shutdown, i.e., by depowering via NC contacts

The requirements stated in [1.3.1] are unaffected.

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

1.3.4 Programmable controllers shall be non-interacting and in case of fault shall 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 workingpoint settings shall be capable of being locked in the operating position.

1.3.6 Switchgear interfaces shall 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 shall 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 vehicle's power supply which may be caused by switching operations. If not more detailed otherwise at the feeding of the remotely operated vehicle wiring bound interference voltages and quick transient interference factors according to IEC 610045, severity level 3 shall be considered.

Where equipment is supplied from static converters, allowance shall be made for periodic voltage pulses. The amplitude depends on the type of converter and shall be investigated in each case.

An overvoltage protection adjusted to the equipment is recommended.

1.4 Power supply

1.4.1 The support vessel's power supply for control, monitoring and safety systems shall comply with the Society's Rules for Electrical Installations [SHIP Pt.4 Ch.9](#).

1.4.2 The power supply shall be monitored and a failure shall be alarmed and registered.

1.4.3 Power supply units for automation equipment shall at least have short circuit and overload protection such that no unsafe operating condition of the vehicle can be created by these.

1.4.4 Automation equipment shall be capable of reliable operation with the voltage and frequency deviations mentioned in the in [SHIP Pt.4 Ch.8 Sec.2 \[1.2\]](#).

2 Control station

For monitoring and controlling the ROV a control station or console shall be provided aboard the support vessel (in a mobile container or permanently installed in the support vessel). All important data related to the operation of the ROV shall be displayed. This includes all controls and monitors, including TV and communications facilities.

The instruments for supervising, open and closed loop control and operating of the ROV shall be grouped and arranged on ergonomic principles at the control stand.

All monitoring and control devices shall be unambiguously labelled and marked.

Limit values shall be marked for analogous measuring instruments. In case of reaching limit values on digital indicating instruments, an alarm shall be provided.

As far as feasible and rational, initiated control functions shall be indicated optically at the control station.

No plants or systems that are impairing the supervision and operation of the ROV shall be installed in the area of the control station.

The prerequisites which shall be made available for the control station by the support vessel are defined in [Ch.6 Sec.12 \[2\]](#).

3 Sensors and actuators

All devices for registering the operating conditions of remotely operated vehicles as well as the belonging actuators shall be approved by the Society and shall be type tested.

4 Data transfer systems

For the use of data cables it shall be guaranteed that the specified data volume per time unit will be transmitted without disturbances under all operating conditions.

In case of a failure of the data transfer, the ROV has to reach a defined and safe operating condition.

If secondary "data for payloads" shall be transferred with data lines, these shall be transmitted independently from the data lines for the operation of the ROV.

5 Navigation and locating equipment

5.1 General

5.1.1 Principally the regulations of the flag state, respectively of the competent authorities, shall be considered.

5.1.2 All the electronically operated navigation and locating equipment necessary to the safety of the ROV shall be connected to the submersible's emergency power supply. It's operational or stand-by status shall be clearly indicated at the control station.

5.1.3 As far as is feasible and rational, remotely operated vehicles shall be equipped with an automatic emergency locating device (pinger). Locating devices shall be harmonized with those on the support ship.

Guidance note:

If a launcher is provided, it can be favourable to equip it also with an emergency locating device (pinger).

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.4 ROVs shall be equipped with suitable signal systems (e.g., flashing light), which enable a quick detection of the surfaced ROV.

5.1.5 For better visibility of the ROV at the water surface, submersibles shall be provided with contrast colour painting or reflection material, applying preferably the colours orange, yellow or red.

SECTION 7 LAUNCHER

1 General

1.1

Launcher shall serve to bring the ROV from the deck of the support vessel with assistance of the launch and recovery system in a water depth where no essential influence of surface waves occurs anymore. By this the actual mission of the ROV can be started from this position and can also be finished in this position again. Compare also [Figure 1](#).

1.2

For a ROV for greater depths the local mobility and manoeuvrability of the ROV shall be increased by lowering the launcher to greater depths and to connect it with a primary umbilical. From the launcher to the ROV only a relative short secondary umbilical need then to be installed.

1.3

Special protection of the ROV can be provided especially during launch and recovery if the launcher is equipped with a garage for the ROV.

1.4

Measures to reduce or even avoid the transformation of the movements of the support vessel in the seaway to the coupling respectively the garage part of the launcher are recommendable. They shall be agreed in advance with the Society and it will be to decide, if and how relevant practical trials are proven or are still to be performed.

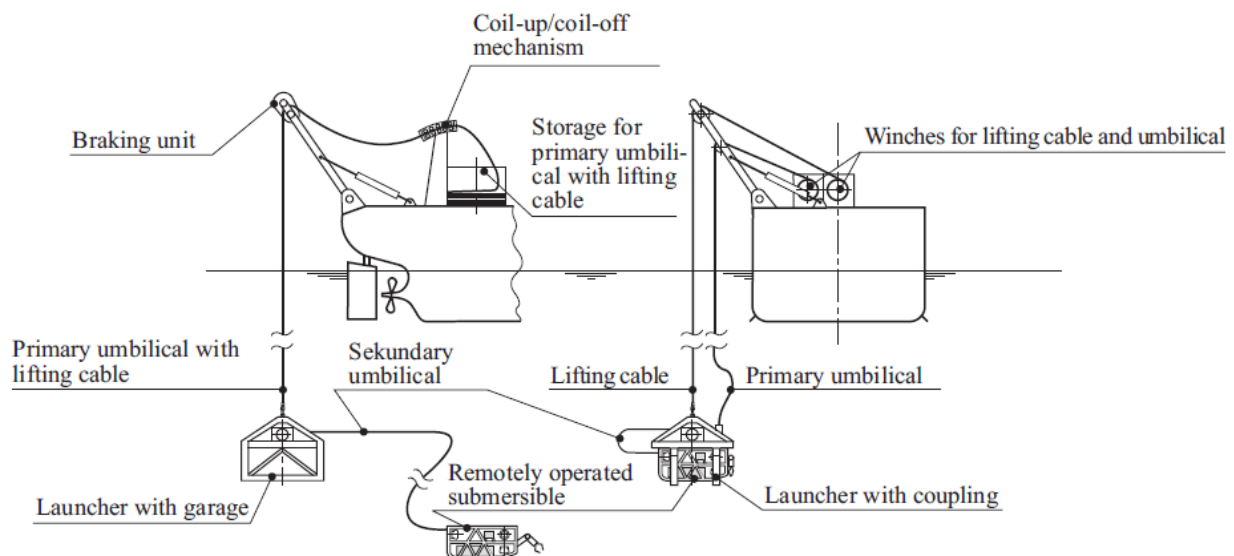


Figure 1 Possibilities for the application of a launcher for non-autonomous vehicles (ROV)

2 Basic requirements

2.1

The suspension of the launcher shall be so designed that a turning of the launcher and, if existing, also of the garage will be reduced as this would render the recovery of the ROV more difficult.

2.2

If the launcher is suspended on the launch and recovery device suitable measures shall be taken against excessive swinging caused by ship movements.

2.3

If no garage for the ROV is provided, the ROV shall be suspended with a suitable coupling device under the construction of the launcher. Adequate guidance devices to the coupling points shall be installed on the launcher. Concerning the successful coupling and decoupling procedures including locking, a feedback signal is required to the control stand on the support vessel.

2.4

For the umbilical winch on the launcher the same requirements as defined for the winches on the support vessel are valid analogously.

2.5

To facilitate the control and monitoring of the procedures for start and recovery of the ROV and also to be able to overlook and check the surrounding area of the launcher an illumination system and adequate video cameras shall be installed. This can also be safeguarded by other suitable measures.

2.6

For the equipment for acoustic position finding the same requirements as defined for devices on manned submersibles are valid.

2.7

For the equipment like hydraulic systems and electrical installations the same requirements as for manned submersibles are valid.

3 Garage

If the launcher is equipped with a garage, the following requirements shall be met:

- a) The supporting structure of the cage shall be adequately robust to be able to endure impacts and shall be equipped with fenders if needed. For the requirements on strength see [Pt.4 Ch.7](#) and [Pt.3 Ch.2](#).
- b) Adequate guidance devices or other aids for parking (e.g., sensors) shall be provided to facilitate the parking of the ROV in the garage.
- c) After the complete entrance in the garage the ROV shall be interlocked/before the exit it shall be unlocked. About these procedures a feedback signal to the control stand on the support vessel is required.

4 Lifting and coil-up/coil-off equipment for umbilicals

Launcher and garage described above need a lifting system which is similar as for manned submersibles. The requirements for such a system are defined in [Ch.6 Sec.11](#).

As there are no persons involved in the recovery procedures, the static test load after assembly can be reduced from 2.2 times the safe working load SWL to 2.0 times SWL.

The detailed requirements for the coil-up/coil-off mechanism are defined in [Pt.4 Ch.5 Sec.2](#).

DNV GL

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