Contents

RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part T SUBMERSIBLES

Chapter 1 GENERAL

1.1 General

1.1.1 Scope

1 The requirements specified in this Part apply to the following submersibles having pressure hulls and to their support systems.

(1) Submersibles operated in unrestricted service areas and supported by their mother ship

(2) Submersibles operated in designated service areas and supported by their support ship and the land support station

2 Submersibles and their support systems are to comply with the requirements specified in this Part, notwithstanding those specified in other Parts except for **Chapter 1, Part A** and **Part B**.

1.1.2 Special Submersibles

Special submersibles and their support systems to which the requirements of this Part are not directly applicable are to be at the discretion of the Society taking their maximum diving depth, operation procedure, etc. into consideration.

1.1.3 Equivalency

Submersibles and their support systems which do not comply with the requirements in this Part may be accepted when they are examined and considered to be, equivalent to those specified in this Part by the Society.

1.1.4 Additional Requirements*

The Society may apply additional requirements where deemed necessary.

1.1.5 Operation Manuals

1 Operation manuals which include the following items are to be provided on board to ensure the safety of the submersible and one set of copies is to be submitted to the Society.

(1) Maximum diving depth and other operational diving depth

(2) Handling of hatches for access openings on the pressure hull

(3) Operation of machinery, equipment and instruments

(4) Sequence of submerging and surfacing

(5) Changes in gravity of sea water, compressive deformation due to diving depth and changes in buoyancy due to temperature of sea water

(6) Interior atmosphere to maintain an anticipated condition for persons in the pressure hull with regard to O_2 or air supply, CO_2 removal, air conditioning and a allowable limits for toxic gases

(7) Increase and decrease of interior pressure, where the pressure hull is arranged to increase its interior pressure

(8) Periodical and routine maintenance

(9) Routine check-up

(10) Use of life-saving appliances

(11) Use of fire extinguishing apparatus and plan for fire protection

(12) Handling of accumulator batteries (including procedure for charging and expected life of accumulator batteries)

(13) Maximum speed and limits of trim in both surface and underwater conditions and crash astern performance

(14) Weather conditions and sea states for permitting in service

(15) Control of fire in cabins

(16) Emergency surfacing

(17) Provision for support and rescue in emergency condition (including support divers and cranes or winches to lift up)

(18) Communication with other ships or land facilities

(19) Others considered necessary

2 The operation manuals for submersibles using support system of their support ship and land support station are to include the following items in addition to those specified in **-1**.

(1) Control of persons on board to take seats in balanced condition

(2) Action in emergency condition with regard to communication, manoeuvring and control of persons' disembarkation

1.1.6 Stability*

1 Submersibles are to have a sufficient stability while being on the surface, submerging or surfacing and being underwater.

2 Under all service conditions including drop weights being jettisoned, submersibles are to have the centre of gravity lower than that of buoyancy and to maintain heel and trim within the range for the safety reason and the operational reason of the equipment.

3 Submersibles are not to produce excessive heel and trim under the condition that persons on board inadvertently move or shift to one side or one end.

Chapter 2 DEFINITIONS

2.1 General

2.1.1 Submersibles

Submersibles are self-propelled ships having facilities for submerging and surfacing by means of their own buoyancy control systems without supply of power from other ships.

2.1.2 Support Systems

Support systems are total back-up systems having functions of housing, operation, rescue and maintenance of the submersible and accommodation of persons on board.

2.1.3 Designated Service Areas

Designated service areas are the sea areas designated by the Administration and the following items at least are specified.

(1) Depth around the course in service
(2) Current around the course in service
(3) Obstacle around the course in service
(4) Discrimination of course in service
(5) Traffic amount on the surface
(6) Disposal of waste from the surface
(7) Distance from the land

2.1.4 Mother Ships

Mother ships are ships having all functions required for the support systems of the submersible operated in unrestricted service areas and being engaged in support works by always staying on the surface under which the submersible is diving.

2.1.5 Support Ships

Support ships are ships having partial functions required for the support systems of the submersible operated in designated service areas and being engaged in support works such as communication with the submersible and other ships and/or the land support station consisting the support systems by always staying on the surface under which the submersible is diving.

2.1.6 Maximum Diving Depth

Maximum diving depth is the maximum depth to which the submersible can dive safely, being specified by the distance from the bottom of keel to the water surface.

2.1.7 Design Diving Depth

Design diving depth is the depth specified below.

(1) For submersibles with a spherical pressure hull, the depth specified in **2.1.6**
(2) For submersibles with a pressure hull other than specified in **(1)**, the depth specified in **2.1.6** plus 1/8 length of the pressure hull.

2.1.8 Pressure Hulls

Pressure hulls are shell structure taking persons and equipment inside and being capable of withstanding an external pressure corresponding to the diving depth.

2.1.9 Pressure Enclosures

Pressure enclosures are shell structure taking equipment inside and being capable of withstanding an external pressure corresponding to the diving depth.

2.1.10 Maximum Design Mission Time

Maximum design mission time is the maximum designed duration during which normal dives are available without any change or charge of expendable supplies.

2.1.11 Buoyancy Control Systems

Buoyancy control systems are the systems to obtain buoyancy of the submersible necessary to operate at any diving depth including buoyancy tank systems, ballast tank systems and drop weights jettisoning systems.

2.1.12 Trim Control Systems

Trim control systems are the systems to control trim of the submersible within an allowance limit at any diving depth.

2.1.13 Manoeuvring Systems

Manoeuvring systems are the systems to move or turn the submersible in every direction under normal trim and neutral buoyancy condition including propelling systems and controlling systems.

Chapter 3 HULL CONSTRUCTION

3.1 General

3.1.1 Freeboard while Being Surface*

1 Submersibles are to have proper freeboard while being surface.

2 Upper edges of access openings of the pressure hull planned to be used for embarking and disembarking on the surface are to have sufficient height above the water surface while being surface.

3.1.2 Consideration against Corrosion

Important parts of the submersible considered being liable to corrode are to be properly protected by means of increasing in thickness or the like against corrosion by taking the materials used, environmental conditions, etc. into consideration.

3.1.3 Special Consideration against Damages from Outside*

1 Pressure hulls and pressure enclosures are to be properly protected to prevent them from damages due to contact with foreign obstacles such as the mother ship or the support ship.

2 Pressure hulls and pressure enclosures are to be properly protected against collision, etc. with foreign objects and the like.

3 Hull structural members other than pressure hulls and pressure enclosures considered being liable to suffer mechanical damages which affect the safety of the submersible are to be properly protected or strengthened.

3.1.4 Consideration while being Lifted, etc.

Submersibles are to have sufficient strength and stability while being lifted (including in an emergency condition), housed and towed.

3.1.5 Consideration for Submersibles while Sailing on the Surface

Submersibles intended to sail on the surface are to be so constructed as to be able to watch the water surface with the hatches closed or to be provided with suitable devices in lieu of such a construction. Where, however, submersibles can sail safely with the hatches opened, this requirement may not apply.

3.1.6 Mooring Fittings

Submersibles are to have means being capable of mooring to the mother ship, the support ship or piers by use of chain or rope.

3.2 Materials and Welding

3.2.1 Materials*

1 Materials used for important structural members such as pressure hulls and pressure enclosures are to be of those comply with the requirements specified in **Part K**.

2 Materials used for view port windows are to be of those comply with the requirements specified in a standard considered appropriate by the Society.

3 Non-metal materials used for packings, buoyancy tanks, etc. are to be of those comply with a national standard considered appropriate by the Society or the equivalent thereto.

3.2.2 Welding Materials and Procedure

1 Welding materials and procedure used for important structural members are to be of those comply with the requirements specified in **Part M**.

2 Post welded heat treatments for relieving residual stresses are to be conducted on pressure hulls or pressure enclosures where considered necessary by the Society taking the construction, materials, shapes of welding joints, welding procedure and the like into consideration.

3.3 Pressure Hulls and Pressure Enclosures

3.3.1 Fire-proof Materials*

1 Materials composing pressure hulls or pressure enclosures are to be non-combustible. However, this requirement may not apply to materials used for view port windows, packings, etc. and considered appropriate by the Society.

2 Materials used inside pressure hulls or pressure enclosures are to be non-combustible. However, in such unavoidable uses as for paints and chairs, etc., materials passed through tests considered appropriate by the Society may be used.

3.3.2 Construction and Strength of Pressure Hulls and Pressure Enclosures*

1 Pressure hulls and pressure enclosures are to have strength not to collapse at an external pressure corresponding to at least twice the design diving depth. Where, however, for submersibles whose design diving depth is 600 *metres* or more, the external pressure mentioned above may decrease to that corresponding to 1.5 times the design diving depth plus 300 *meters* subject to the collapsing strength taking the initial imperfection of fabrication into consideration has been sufficiently confirmed by means of experiments and analysis and considered appropriate by the Society.

2 Pressure hulls and pressure enclosures are to be designed to have such strength that the stresses caused an external pressure corresponding to the design diving depth are sufficiently smaller than the yielding point of the materials used.

3 Submersibles are to have lifting lugs with such strength as to be capable of being lifted to the water surface.

4 View port windows and hatch covers of the pressure hull or the pressure enclosure are to have such strength as to be equivalent or more to that of the main bodies.

5 Opening parts of the pressure hull or the pressure enclosure are to have such strength as to be equivalent or more to that of the main bodies having no openings.

6 Parts where view port windows, hatch covers, and valves, etc. are fitted to and where pipes and cables penetrate through the pressure hull or the pressure enclosure are to have sufficient watertightness. Movable parts and their bearings penetrating through the pressure hull or the pressure enclosure are to have enough watertightness to ensure the safe service of the submersible.

7 Openings on the pressure hull or the pressure enclosure are to be necessary minimum in number and to be located at easily accessible positions.

8 View port windows are to be protected in such a way specified below.

(1) Protection means are to be provided to prevent contacts with foreign objects.

(2) For submersibles operated in designated service areas, protection covers such as vinyl sheets are to be provided, if necessary, to protect surfaces of the windows.

9 Acrylic plastic windows are to have construction and strength considered appropriate by the Society.

10 Access openings of the pressure hull are to have hatches with construction being capable of handling from each side of the hatches and to have means to indicate the opening/closing condition inside the pressure hull.

3.4 Structural Members other than Pressure Hulls and Pressure Enclosures

3.4.1 General

Structural members composing the hull structure other than the pressure hull and the pressure enclosure are to have sufficient strength withstanding all operating conditions of the submersible in a normal service.

Chapter 4 MANOEUVRING SYSTEMS, ETC.

4.1 Manoeuvring Systems, etc.

4.1.1 General

1 Buoyancy control systems, trim control systems and manoeuvring systems (hereinafter referred to as "manoeuvring systems, etc." in this Chapter) are to be designed on the fail-to-safe principle in such a way that one fault does not result in other fault taking overall safety of the submersible and personnel into consideration.

2 Manoeuvring systems, etc. are to effectively operate under environmental conditions of the location and the planned operating conditions. Moreover, these systems, are to be capable of operating when the submersible is inclined at any angle of trim up to 30 *degrees* or heel up to 15 *degrees* or when the submersible is rolled up to 60 *degrees* on the surface. As for the systems not used while the submersible being surface, consideration of the operation during rolling is not necessary, but they are to be capable of operating efficiently after the submersible has rolled up to 60 *degrees*.

3 Instruments or indication devices to monitor the operation of the manoeuvring systems, etc. are to be provided at easily visible positions in the manoeuvring station. Where, however, these systems are installed in such a position that their operations can be directly watched from the manoeuvring station, this requirement may not apply.

4.1.2 Buoyancy Control Systems*

1 Buoyancy tank systems

Submersibles are to have buoyancy tank systems which are capable of holding proper freeboard being surface afloat and complying with the followings.

(1) Buoyancy tanks which have following construction and function are to be provided.
  (a) The tanks are to have such construction that an internal pressure can be equalized to an external pressure in the underwater.
  (b) The tanks are to have such construction as being divided into properly and their arrangements are to ensure the function specified in **1.1.6**.
  (c) The tanks are to have vent valves on each compartment to accumulate or discharge internal air.
  (d) The tanks are to have such construction as to keep the necessary amount of air for buoyancy inside the tanks while surfacing or being surface even when the submersible is excessively inclined.
  (e) The tanks are to have such construction that internal air can easily be discharged when submerging.

(2) High pressure bottles containing compressed air and piping systems for blow water off the tanks are to be provided. The arrangements of the bottles and piping systems are to be properly protected against damages from outside.

(3) A pressure indicating device for the compressed air mentioned in **(2)** is to be provided at the manoeuvring station.

(4) Valves concerned to the operation of buoyancy tank systems are to be capable of handling at the manoeuvring station.

2 Ballast tank systems

Submersibles are to have ballast tank systems which are capable of controlling the weight in the underwater and complying with the followings.

(1) Ballast tanks with pressure resisting construction are to be provided.

(2) Ballast pumps to charge and discharge water in the tanks are to be provided.

(3) The volume of water in the tanks are to be monitored at the manoeuvring station.

3 Drop weights

(1) Submersibles are to have drop weights which are capable of surfacing the submersible by being jettisoned. Where submersibles obtain buoyancy by blowing water off the ballast tanks, drop weights are to have a sufficient mass specified in **(a)** or **(b)** bellow whichever is larger.
  (a) The mass corresponding to sea water volume of all ballast tanks and all trim tanks minus the planned sea water volume. However, when the ballast tanks are so arranged capable of being deballasted by compressed air, the mass may be decrease to the half of that specified above.
  (b) The mass corresponding to seawater volume of the largest single possible floodable pressure enclosures or pressure bottles.

(the volume of contents may be subtracted.)

(2) Drop weights are to be capable of being jettisoned from inside the pressure hull by reliable two systems at the maximum diving depth. However, when the submersible is so designed as to have another surfacing means considered appropriate by the Society, the systems mentioned above may be a single system.

4.1.3 Trim Control Systems

Submersibles are to have trim control systems complying with the followings. Where, however, considered appropriate by the Society, the systems may be in common with the ballast tank systems specified in **4.1.2-2** or may be another control method.

(1) Trim tanks are to be provided in fore and aft positions.

(2) Trim pumps for inter-tank shifting of liquid are to be provided.

(3) The level of the trim tanks are to be monitored at the manoeuvring station.

4.1.4 Manoeuvring Systems

1 Submersibles are to have manoeuvring systems which are capable of effectively controlling the submersible under all planned service conditions.

2 Manoeuvring systems are to have reliable function and easy operation.

3 Instruments for the systems are to have such an accuracy to ensure a safe operation of the submersible.

4 Propellers, shaftings, reduction gears, prime movers and the like are to comply with the followings.

(1) They are to have construction and strength considered appropriate by the Society.

(2) The output of the systems are to be sufficient to keep speed for control the submersible and to provide an astern power capable of braking effectively when operating condition is changed from ahead to astern.

4.1.5 Depth Gauges

Submersibles are to have depth gauges which are capable of monitoring the depth specified below or more at easily visible positions in the manoeuvring station. The submersible is to have at least two depth gauges working independently.

(1) For submersibles with the maximum diving depth of 1,000*m* or less, 1.25 times the maximum diving depth

(2) For submersibles with the maximum diving depth of not less than 1,000*m*, 1.1 times the maximum diving depth

4.1.6 Means for Emergency Releasing

Where submersibles have balanced chains, anchors or the like which are liable to be trapped by rocks or obstacles on the sea bed, proper means are to be provided such as a releasing means of them easily operable from inside the pressure hull.

4.2 Construction and Arrangements of Machinery, Equipment and Piping Systems

4.2.1 General

1 Machinery, equipment and pipings installed inside the pressure hull are to be of free from outbreak and leakege of inflamable or toxic gases.

2 Machinery, equipment and pipings installed inside the pressure hull or the pressure enclosure are to be made of materials complying with the requirements specified in **3.3.1-2.** Materials used for those installed inside the pressure enclosure are to be of fire-retardant ones.

3 In unavoidable uses of materials not complying with **-2** above, the materials are to be of minimum outbreaking of smoke and toxic gases when burnt and consideration is to be given to minimize initiation and propargation of fire.

4 Machinery, equipment and pipings installed outside the pressure hull or the pressure enclosure used under an external pressure are to have sufficient strength to withstand an external pressure corresponding to the design diving depth.

5 Machinery, equipment and pipings installed outside the pressure hull or the pressure enclosure liable to corrode are to be properly protected against corrosion taking the materials used into consideration.

6 Moving parts of machinery liable to injure personnel are to be protected to minimize any danger to personnel.

7 Means to detect leakage of sea water are to be provided at positions having penetrators through the pressure hull and expecting no watch by person.

8 Handles of hatch covers, valves, other equipment and the like are to have means to indicate the opening/closing condition. Valves are to be marked or to have appropriate means for identification to avoid misoperations.

4.2.2 Construction and Materials of Machinery and Equipment

1 Pumps used for buoyancy control systems, trim control systems or manoeuvring systems are to comply with the followings.

(1) The requirements specified in **Part D**.

(2) The pumps are to have a sufficient flow rate under a delivery pressure corresponding to 1.1 times the maximum diving depth or more and to be capable of discharging under an external pressure corresponding to 1.2 times the maximum diving depth.

(3) Check valves are to be provided at the delivery side of the pump. Where, however, the stop valve with a visual alarm to indicate its open is provided at the delivery side of the pump, this requirement may not apply.

2 Pressure vessels, tanks and the like are to comply with the followings.

(1) Pressure vessels, tanks and the like subjected to an internal pressure are to comply with the requirements specified in **Part D** with regard to their construction, materials used and welding.

(2) High pressure bottles are to be of those complying with a standard or regulations considered appropriate by the Society.

(3) Pipes penetrating through the pressure hull are not to lead to tanks installed inside the pressure hull.

4.2.3 Arrangements of Piping Systems

1 Piping systems penetrating through the pressure hull are to have a stop valve at a position as close as possible to the pressure hull penetrator and easily accessible in the pressure hull and to have rigid construction between the valve and the penetrator.

2 Where piping systems penetrating through the pressure hull have openings at outside the pressure hull, a valves specified below is to be provided at a position as close as possible to the stop valve specified in **-1**.

(1) For piping systems to discharge outside the pressure hull, a check valve or a valve capable of being remotely controlled.

(2) For piping systems to charge inside the pressure hull, a valve capable of being remotely controlled.

3 Piping systems penetrating through the pressure hull are to be located as far as possible at a position easily capable of conducting maintenance and repair works and finding out a leakage.

4.2.4 Materials and Welding of Piping Systems

1 Pipes, valves and fittings of the piping systems subjected to an internal pressure are to comply with the requirements specified in **Part D** with regard to their construction, materials used and welding. The essential piping systems such as those penetrating through the pressure hull are to be considered as Group I piping systems.

2 Piping systems penetrating through the pressure hull are to be designed complying with the requirements specified in **Part D** by taking a pressure corresponding to the maximum diving depth or the maximum operating pressure of the piping system concerned whichever is larger as the design pressure.

4.2.5 Means for Pressure Equalizing

Means are to be provided to equalize the internal pressure to atmospheric pressure gradually prior to the opening of the access hatches to ensure the safe disembarkation in case of the pressure becoming excessively higher than atmospheric pressure.

4.2.6 Control Systems

Control systems for the machinery and equipment concerning to the safety of the submersible and personnel are to comply with the followings.

(1) The control systems are to have reliable function and easy operation to ensure the necessary control such as starting and stopping of the machinery.

(2) The function of automatic and/or remote control systems is to be capable of being manually cancelled. And the important machinery and equipment for the safety of the submersibles and personnel are also to be controlled manually.

(3) The control systems are to be independently constituted each other with regard to the kind, use, etc.

4.2.7 Pingers and/or Transponders

Submersibles are to have means such as pingers, transponders or the like to detect the position of the submersible from the mother ship or the support ship.

4.2.8 Underwater Communication Systems

Submersibles are to have underwater communication systems with a sufficient communicable range to ensure good communication with the mother ship or the support ship.

4.3 Electrical Installations

4.3.1 General

1 Electrical installations are to be fit for marine use and to be effectively and safely operable under environmental conditions of their installed locations.

2 Electrical installations are to be so suitably installed that electrical contacts could not initiate a fire even in oxygen enriched atmosphere.

4.3.2 Power Distribution Systems

Power distribution systems are to be insulated systems and an insulation monitoring device is to be provided so that the insulation level can be monitored.

4.3.3 System Voltage

The system voltage of electrical installations is to be 250 *V* or less.

4.3.4 Protective Devices and Emergency Cut-off Devices

1 Electrical installations are to be protected against every overcurrent including short-circuit. The protective devices are to be capable of breaking the fault circuit so as to minimize damage and risk of fire as well as to keep other sound circuits operable continuously as far as possible.

2 Submersibles are to have devices to cut-off the main source of electric power in case of an emergency condition from an easily accessible position. Where, however, the switchboard is arranged to be easily operable, the circuit breakers on the switchboard may be regarded as the above mentioned devices.

4.3.5 Earthing

Non-current-carrying exposed metal parts of electrical equipment and metal coverings of cables are to be effectively earthed.

4.3.6 Lightings in the Pressure Hull

1 Lightings in the pressure hull necessary for safe operation of the submersible are to be so arranged that failure of any one circuit will not leave the space in darkness.

2 Lighting equipment having the source of electrical power is to be installed at proper positions in the pressure hull.

4.3.7 Main Source of Electric Power

Submersibles are to have main source of electric power having sufficient capacity capable of supplying electrical power for the services as specified below.

(1) For a period of the maximum design mission time for all electrical installations

(2) For a period of 72 *hours* for those specified below

(a) Life support and environmental control systems (excluding those specified in **5.1.2**)

(b) Life-saving appliances

(c) Fire extinguishing apparatus

(d) Underwater communication systems

(e) Pingers and/or transponders

(f) Interior communication systems

4.3.8 Reserve Source of Electric Power

Submersibles are to have reserve source of electric power being independent of the main source of electric power and having sufficient capacity capable of supplying electric power for the services specified in **4.3.7(2)** for the period specified below.

(1) For submersibles operated in unrestricted service areas, the planned surfacing time to reach the surface from the maximum diving depth plus 30 *minutes*

(2) For submersibles operated in designated service areas, 72 *hours*

4.3.9 Electrical Equipment

1 Electrical equipment of the submersible is to be designed and manufactured on the basis of consideration for the environmental temperature range between being housed in the mother ship or the support ship and being submerged.

2 Electrical equipment inside the pressure hull is to be capable of effectively operating under the possible most humid condition by taking the capacity of humidity control devices into consideration.

3 Electrical equipment outside the pressure hull or the pressure enclosure is to be of a submerged type and to have sufficient

function under all planned operating conditions.

4 Electrical equipment liable to condensate water drops inside is to be of at least drip-proof construction and electrical equipment located in the pressure hull is to be so constructed and arranged as to prevent persons from accidentally contacting with the live parts.

5 Switchboards and transformers inside the pressure hull are to comply with the followings.

(1) Switchboards are to be of a dead-front type.

(2) Transformers are to be of a double wound and dry, naturally cooled type and to be so constructed and arranged as to prevent persons from accidentally contacting with the live parts.

6 Electrical installations of submersibles using accumulator batteries for their sources of electrical power are to be effectively operate during the range from fully charged voltage to final discharge voltage.

4.3.10 Accumulator Batteries

1 Accumulator batteries are to comply with the requirements specified in **-2** to **-5** below as well as the requirements specified in **4.3.9-1** to **-4**.

2 Accumulator batteries are to be located where can be free from bilge.

3 Accumulator batteries located inside the pressure hull are to comply with the followings.

(1) The batteries are to be of a sealed type.

(2) The batteries are to be installed in a compartment assigned to them only.

(3) An H_2 detector is to be provided in the compartment specified in **(2)** to detect the H_2 content at or above 1% by volume.

(4) The H_2 detector specified in **(3)** is to be of a certified safe type deemed appropriate by the Society.

(5) Effective means are to be provided to prevent H_2 content in the compartment specified in **(2)** above from exceeding 1% by volume.

4 Accumulator batteries located outside the pressure hull are to be installed in the enclosures specified below.

(1) Enclosures in which pressure can be equalized to an external pressure and having devices to release H_2 gases

(2) Pressure enclosures provided with means against H_2 gases considered appropriate by the Society

5 Accumulator batteries for main source or reserve source of electric power are to be provided with a device to indicate the charged/discharged conditions of the accumulator batteries at an easily visible position.

4.3.11 Cables

1 Cables fitted inside the pressure hull are to be made of materials complying with the requirements in **4.2.1-2**.

2 Cables fitted outside the pressure hull or the pressure enclosure are to be of a water-proof type.

3 Connectors fitted outside the pressure hull or the pressure enclosure or on the openings of them are to have watertight construction.

4 Cables and connectors specified in **-2** and **-3** are to have sufficient function under all planned operating conditions.

5 Penetrating parts of cables through the pressure hull or the pressure enclosure are to be sustained watertightness to ensure the safety of the submersible even in the cases specified below.

(1) In case of the cables being cut off at outside the pressure hull or the pressure enclosure when the cables penetrate through the pressure hull or the pressure enclosure directly

(2) In case of the plugs being disconnected or broken when the cables penetrate through the pressure hull or the pressure enclosure by use of connectors

6 Cables are to be fixed to frames, pressure hulls, guide plates and the like in ways suitable for the kind of the cables.

7 Cables fitted outside the pressure hull or the pressure enclosure are to be located at positions free from damages from outside as far as possible. When located at undesirable positions, proper means for protection are to be provided.

4.4 Fire Extinguishing Apparatus

4.4.1 Portable Fire Extinguishers

Submersibles are to have portable fire extinguishers producing no toxic gases as far as practicable.

Chapter 5 LIFE SUPPORT AND ENVIRONMENTAL CONTROL SYSTEMS AND MEANS OF ESCAPE

5.1 Life Support and Environmental Control Systems

5.1.1 Humidity Removal Devices

Where the increase of humidity is considered liable to affect the functions of the electrical equipment specified in 4.3.7(2), submersible are to have humidity removal devices having a removal capacity of humidity for the maximum design mission time plus 72 *hours*.

5.1.2 Breathing Gas Systems*

Submersibles are to have breathing gas systems capable of breathing for the maximum design mission time for the maximum number of persons on board. In this case, the breathing gas systems are to be composed of CO_2 removal systems, atmospheric circulation systems and air or O_2 supply systems. The atmospheric circulation systems are to have a sufficient flow rate to homogenize the contents of atmosphere inside the pressure hull.

5.1.3 Reserve Breathing Gas Systems*

Submersibles are to have reserve breathing gas systems with a removal capacity of CO_2 and a supply capacity of air or O_2 for 72 *hours* for the maximum number of persons on boad in addition to the systems specified in 5.1.2. In this case, high pressure bottles and piping systems installed outside the pressure hull are to be independent from those used for the systems specified in 5.1.2 and to be arranged effectively protected against damages from outside.

5.1.4 Monitoring Systems

1 Monitoring systems of the following items are to be provided in duplicate inside the pressure hull.

(1) O_2 content of interior atmosphere (One of the monitoring systems is to be provided with high and low content alarms.)

(2) CO_2 content of interior atmosphere (One of the monitoring systems is to be provided with a high content alarm.)

2 A barometer, a thermometer and a humidity meter are to be provided inside the pressure hull.

5.2 Means of Escape

5.2.1 General*

1 Submersibles are to have an emergency access opening in addition to the opening for normal use, except when considered unavoidable by the Society.

2 The notice of no smoking and locations of exits and escape routes are to be shown at inside the pressure hull.

Chapter 6 SUPPORT SYSTEMS

6.1 Support Systems

6.1.1 General*

1 Support systems, in general, are to be composed of the support facilities specified below.

(1) Towing systems which have sufficient capacity and strength to tow the submersible safely and passed through tests considered appropriate by the Society

(2) Launch and recovery systems or cranes which are designed and manufactured by applying the requirements of the **Rules for Cargo Handling Appliances** by regarding the design lifting load or a load considered appropriate by the Society as the safe working load

(3) Communication systems with the land support station or other ships

(4) Devices to detect positions of the submersible corresponding to those specified in **4.2.7**

(5) Underwater communication systems corresponding to those specified in **4.2.8**

(6) Others deemed necessary by the Society in consideration of the operation form of the submersible

2 The function of support systems are to be maintained by following.

(1) For submersibles operated in unrestricted service area, the mother ship

(2) For submersibles operated in designated service area, the support ship and the land support station.

6.1.2 Mother Ships

1 Mother ships are to be of classed with the Society.

2 Mother ships are to be provided with the support facilities specified in **6.1.1-1(1)** to **(6)**.

6.1.3 Support Ships

1 Support ships are to be of those considered appropriate by the Society by taking the construction and operation form of the submersible into consideration.

2 Support ships are to have at least the support systems specified in **6.1.1-1(3)** to **(6)**.

Chapter 7 TESTS

7.1 General

7.1.1 Scope

1 Tests for hulls and installations of submersibles are to be in accordance with the requirements in this Chapter.

2 Tests specified in this Chapter which are deemed difficult by the Society to be carried out on real subjects may be substituted by tests on suitable models or samples.

7.1.2 Additional Tests

Tests not specified in this Chapter may apply where deemed necessary by the Society.

7.1.3 Exemption of Tests

As for the machinery or equipment holding adequate certificates, the Society may exempt the tests specified in this Chapter partly or wholly.

7.2 Tests

7.2.1 Tests for Pressure Hulls and Pressure Enclosures*

Pressure hulls and pressure enclosures and view port windows, hatch covers, penetrators, etc. fitted on the openings of them are to undergo the tests specified below.

(1) Radiographic examinations are to be conducted on the whole length of butt welded parts of the pressure hull and the pressure enclosure to confirm no harmful defect exists. Where, however, approved by the Society, suitable non-destructive examinations may partly substitute for the radiographic examinations.

(2) Upon completion of works of the pressure hull, the alignment of the pressure hull is to be measured and confirmed that it is within an allowable tolerance deemed appropriate by the Society.

(3) View point windows and hatch covers (excluding conical sheet hatches) fitted on the openings of the pressure hull and the pressure enclosure are to be hydrostatically tested at an external pressure corresponding to 1.25 times the design diving depth and confirmed no leakage nor injurious deformation exists. As for the acrylic view port windows, the temperature of pressurizing medium at the hydrostatic test is to be at least 14℃ lower than the design temperature, but not to be less than 0℃

(4) Pressure hulls and pressure enclosures are to be hydrostatically tested after all fittings have been fitted at an external pressure specified below and confirmed that they have sound watertightness. (Movable parts and their bearings penetrating through the pressure hull or the pressure enclosure are to have enough watertightness to ensure the safe service of the submersible.) And pressure hulls are to be confirmed that strains measured at proper points are within the proper value and no injurious deformation exists by measuring, for example, the spherical accuracy of the pressure hull.

(a) For submersibles with the maximum diving depth of 500m or less, an external pressure corresponding to 1.25 times the design diving depth

(b) For submersibles with the maximum diving depth of more than 500m but not more than 1,000m, an external pressure corresponding to 50m plus 1.15 times the design diving depth

(c) For submersibles with the maximum diving depth of more than 1,000m, an external pressure corresponding to 150m plus 1.05 times the design diving depth but not less than an external pressure corresponding to 1.1 times the design diving depth

7.2.2 Tests for Machinery, Equipment and Piping Systems

1 Piping systems are to be tested in accordance with the requirements specified in **Part D**. In this case, the essential piping systems such as those penetrating through the pressure hull are to be tested as the Group I piping systems. And for piping systems which may be subjected to an internal pressure when a part outside the pressure hull or the pressure enclosure is damaged, a test pressure of hydrostatic test is to be of that corresponding to 1.5 times the design diving depth or to be 1.5 times the design pressure whichever is larger.

2 Casings of machinery subjected to an internal pressure such as those of pumps are to be hydrostatically tested at a test pressure

of 1.5 times the design pressure.

3 Pumps used for buoyancy control systems or trim control systems are to be tested to comply with requirements specified in 4.2.2.

4 Piping systems, equipment and the like fitted outside the pressure hull or the pressure enclosure or on the openings of those subjected to an external pressure corresponding to the diving depth are to be hydrostatically tested at a test pressure of 1.5 times the design diving depth. Where, however, the Society may exempt the test or modify a test pressure taking construction and usage of the piping systems, equipment and the like into consideration.

5 Pressure indicating devices for high pressure bottles, liquid level indicating devices for ballast tanks and for trim tanks and instruments specified in 5.1.4-1 are to undergo adjustment test.

6 Electrical Installations are to be subjected to the following tests.

(1) Insulation resistance test

(2) Charging and discharging test on the accumulator batteries specified in 4.3.10

(3) Performance test on the protective devices and cut-off devices specified in 4.3.4

(4) Watertightness test by a method approved by the Society on the penetrating parts of cables specified in 4.3.11-5

(5) Tests specified in Part H for equipment and cables installed inside the pressure hull or the pressure enclosure

(6) Tests specified in Part H and a hydrostatic test at an external pressure corresponding to 1.5 times the design diving depth for cables installed outside the pressure hull or the pressure enclosure

(7) Hydrostatic tests at an external pressure corresponding to 1.5 times the design diving depth on connectors installed outside the pressure hull or the pressure enclosure

(8) Tests correspondingly regarded to those specified in Part H for equipment installed outside the pressure hull or the pressure enclosure, by taking their environmental conditions into consideration

7 The following systems or devices and their electric sources of power including equipment composing them are to be tested by methods approved by the Society to confirm their performances.

(1) Buoyancy control systems

(2) Trim control systems

(3) Manoeuvring systems

(4) Devices specified in 4.1.5

(5) Devices specified in 5.1.1 to 5.1.4

7.2.3 Inclining Tests

Upon completion of all works, submersibles are to undergo inclining tests to determine particulars concerned to stability. The determined particulars are to be stated in the operation manuals specified in 1.1.5.

7.2.4 Sea Trials

Upon completion of all works, submersibles are to undergo sea trials including the items specified below.

(1) Operation tests on manoeuvring systems and buoyancy control systems and performance tests on underwater communication systems at the maximum diving depth

(2) Performance tests on underwater propelling speed in every direction and operation tests on functions of surfacing, submersing, turning and stopping and performance tests on life support and environmental control systems, etc. at proper diving depth

(3) Performance tests on propelling speed in every direction on the surface if the submersible is intended to navigate on the surface and operation tests on functions of turning and stopping and function tests on open/close indicating devices of access openings.

7.2.5 Tests for Support Systems

Facilities for support systems are to undergo the tests specified below.

(1) Performance tests on underwater communication systems and devices to detect positions of the submersible on sea trials at the maximum diving depth

(2) The following tests on towing systems, housing systems, launch and revocery systems or cranes for lifting the submersible

(a) As for the towing systems, tests to confirm the effectiveness of the systems

(b) As for the housing systems, tests to confirm the effectiveness of the systems

(c) As for the launch and recovery systems or cranes for lifting the submersible, tests correspondingly regarded to those specified in 2.4 and 2.5 of the Rules for Cargo Handling Appliances

Contents

GUIDANCE FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part T SUBMERSIBLES

T1 GENERAL

T1.1 General

T1.1.4 Additional Requirements

The wording "additional requirements where deemed necessary" in **1.1.4, Part T of the Rules** means, for example, the case the Government of the State whose flag the submersible is entitled to fly has national regulations.

T1.1.6 Stability

The "all service conditions including drop weights being jettisoned" in **1.1.6-2, Part T of the Rules** includes the following conditions.

(1) The condition that the buoyancy tanks (the volume of the maximum tank or that of not less than one half of the total volume of tanks whichever is larger) are filled with sea water and the drop weights are jettisoned and the expected number of persons at embarking or disembarking are standing on the freeboard deck while being surface.

(2) The condition that all buoyancy tanks are blown off and the drop weights are still fastened and all persons on board are standing on the freeboard deck while being surface.

T3 HULL CONSTRUCTION

T3.1 General

T3.1.1 Freeboard while Being Surface

The wording "sufficient height above the water surface" in **3.1.1-2, Part T of the Rules** means 45 *cm* or more above the upper deck for submersibles operated in designated service areas.

T3.1.3 Special Consideration against Damages from Outside

The wording "properly protected against collision, etc. with foreign objects" in **3.1.3-2, Part T of the Rules** means such a protection for the pressure hull as to be capable of absorbing the energy of collision at a speed of 1.0*m/sec.* for the fore-aft direction and a speed of 0.5*m/sec.* for the up-down and right-left directions between the submersible and a rigid flat wall.

T3.2 Materials and Welding

T3.2.1 Materials

The "standard considered appropriate by the Society" in **3.2.1-2, Part T of the Rules** is *ASME PVHO*-1 1987 for acrylic plastic castings used for view port windows.

T3.3 Pressure Hulls and Pressure Enclosures

T3.3.1 Fire-proof Materials

The "tests considered appropriate by the Society" in **3.3.1-2, Part T of the Rules** are "Smoke and Toxicity Test" and "Test for Surface Flammability" carried out in accordance with the *FTP* Code defined in **3.2.23, Part R of the Rules** or the equivalent thereto.

T3.3.2 Construction and Strength of Pressure Hulls and Pressure Enclosures

The "construction and strength considered appropriate by the Society" in **3.3.2-9, Part T of the Rules** are those to comply with the requirements specified in *ASME PVHO*-1 1987 by accounting the design pressure and the design temperature as follows.

(1) Design pressure

The design pressure is to be a pressure corresponding to the design diving depth or more.

(2) Design temperature

For submersibles operated in designated service areas, the design temperature is not to be less than 25℃.

T4 MANOEUVRING SYSTEMS, ETC.

T4.1 Manoeuvring Systems, etc.

T4.1.2 Buoyancy Control Systems

1 The wording "properly protected against damages from outside" in **4.1.2-1(2), Part T of the Rules** means such arrangements considering independency in order to fulfil the followings.

(1) The loss of surfacing function is to be limited so that not less than one half of the total volume of the buoyancy tanks are possible to blow off in case that one of high pressure bottles containing compressed air or their pipings (excluding the part in the pressure hull or the pressure enclosure) is damaged.

(2) Any excessive trim is not to be caused even in such a case of loss of surfacing function mentioned above.

2 One of the "reliable two systems" in **4.1.2-3(2), Part T of the Rules** is recommended to be a fully manual operated system.

3 The "another surfacing means considered appropriate by the Society" in **4.1.2-3(2), Part T of the Rules** is such a means as lifting the submersible directly by using wires.

T5 LIFE SUPPORT AND ENVIRONMENTAL CONTROL SYSTEMS AND MEANS OF ESCAPE

T5.1 Life Support and Environmental Control Systems

T5.1.2 Breathing Gas Systems

The breathing gas systems in **5.1.2, Part T of the Rules** is to comply with the followings.

(1) The systems are to be designed based upon an hourly per man O_2 consumption of at least 0.034*kg* and CO_2 production of at least 0.040*kg*. As for submersibles operated in designated service areas, it is recommended to be designed based upon an hourly per man O_2 consumption of 0.038*kg* and CO_2 production of 0.0523*kg*.

(2) The systems are to be capable of maintaining the O_2 content of the interior atmosphere within the range of 19% to 23% by volume.

(3) The systems are to be capable of maintaining the CO_2 content at or below 1.0% by volume. As for submersibles operated in designated service areas, it is recommended that the CO_2 content should be at or below 0.5% by volume.

(4) The systems are to be composed of at least a shut-off valve, a flowmeter and two flow regulating devices arranged ready for use in case of failure of one device.

T5.1.3 Reserve Breathing Gas Systems

The reserve breathing gas systems in **5.1.3, Part T of the Rules** are to be in accordance with those in **T5.1.2**.

T5.2 Means of Escape

T5.2.1 General

The wording "when considered unavoidable by the Society" in **5.2.1-1, Part T of the Rules** means the case when the length of the pressure hull is 10*m* or less.

T6 SUPPORT SYSTEMS

T6.1 Support Systems

T6.1.1 General

1 Ropes, hooks, shackles, blocks and the like used for the launch and recovery systems or cranes in **6.1.1-1(2), Part T of the Rules** are to comply with the followings.

(1) Ropes are to have such strength that the safety factor for the breaking stress is not less than 5 at the design lifting load of the submersible and to be passed through tests deemed appropriate by the Society.

(2) Hooks, shackles, blocks and the like are to have sufficient strength for the design lifting load of the submersible and to be passed through tests deemed appropriate by the Society.

2 When floating docks are used for the means of housing for the submersible, the docks are to be designed and constructed in accordance with the requirements of the **Rules for Floating Docks** or the equivalent thereto.

T7 TESTS

T7.2 Tests

T7.2.1 Tests for Pressure Hulls and Pressure Enclosures

The "an allowable tolerance deemed appropriate by the Society" in **7.2.1(2), Part T of the Rules** is to be in accordance with the followings except when another standard of fabrication tolerance is used under approval by the Society by submitting documents concerned.

(1) The alignment at butt welded edges on the cylindrical pressure hull is to be such that the maximum offset is not more than 1/10 of the thickness for longitudinal joints and 1/5 for circumferencial joints, or 3*mm* whichever is less. The alignment at butt welded edges for the spherical pressure hull is to be such that the maximum offset is not more than 1/10 of the thickness or 3*mm* whichever is less.

(2) The amount of the sidelong falling of the frames on the cylindrical pressure hull is not to exceed 1/40 of the frame depth for the outside frame and 1/50 for the inside frame or 3*mm* whichever is less.

(3) The alignment at butt welded edges of the face bar of the frames is to be such that the maximum offset is not more than 2*mm* in both directions of depth and width.

(4) As a result of measurements of diameter around circumference inside the pressure hull, absolute values of e_1, e_2 and e_3 in relation to the deviations from a true circle are not to exceed those specified below.

(a) 1/2 of the thickness of the pressure hull or 10*mm* whichever is less for all values

(b) The design values used in the strength calculation of the pressure hull for absolute value of e_2

Where,

e_1 is a distance from a point on the inner side of the pressure hull to the centre of the mean circle by subtracting a radius of the mean circle (*mm*).

e_2 is a maximum absolute value of differences between values of e_1 at a certain point and at another point which are located within a range of an arc length on the inner side of the pressure hull equal to 1/2 of the loblength for cylindrical pressure hulls and equal to the marginal panel width for spherical pressure hulls (*mm*).

e_3 is a difference between a radius of the mean circle and that of the designed circle (*mm*).

In the above, mean circle is a ideal circle whose inner area is equal to that of the pressure hull and a mean value of differences between a radius of the mean circle and that of the pressure hull is minimum.

Design circle is a circle which has a design diameter of the pressure hull.

The 1/2 of the lob-length is an arc length defined as $\sqrt[4]{Dl^2t}$

The marginal panel width is an arc length defined as;

$$\frac{3.1\sqrt{R_1 t}}{\sqrt[4]{3(1-\nu^2)}}$$

D: diameter of designed circle (*mm*)

R_1: local inner radius within the marginal panel width (*mm*)

t: thickness of pressure hull (*mm*)

l: frame space (*mm*)

ν: Poisson's ratio