RULES FOR BUILDING AND CLASSING

UNDERWATER VEHICLES, SYSTEMS AND HYBERBARIC FACILITIES 1990

NOTICE NO. 3 – January 2002

The following Rule Changes are **EFFECTIVE AS OF 1 JANUARY 2002**.

(Note: This Notice is intended as an advance notification of Rule changes which are to become effective on 1 January 2002 and will be superseded by the 2002 edition of the subject Rules to be published later this year.)

SECTION 1 SCOPE AND CONDITIONS OF CLASSIFICATION

1.5 Representation as to Classification *(2002)*

(The following paragraph is added to the end of the existing Paragraph.)

The user of this document is responsible for ensuring compliance with all applicable laws, regulations and other governmental directives and orders related to a vessel, its machinery and equipment, or their operation. Nothing contained in any Rule, Guide, standard, certificate or report issued by the Bureau shall be deemed to relieve any other entity of its duty or responsibility to comply with all applicable laws, including those related to the environment.

1.21 Classification Symbols

1.21.4 Transfer from Other Recognized Classification Societies *(2002)*

(New paragraph 1.21.4 is added and the current 1.21.4 is renumbered 1.21.5.)

The Committee will consider hull, equipment or machinery built to the satisfaction of the Surveyors of the Bureau in accordance with plans that have been approved to the Rules of another recognized classification society with verification of compliance by the Bureau. Such consideration will be conducted per 1-1-4/3.5 of the *Rules for Building and Classing Steel Vessels*.

1.29 Submission of Plans, Calculations and Data

*(Introduced the groupings **a**, **b**, **c** and **d** with titles in 1.29.2 and expanded list of plans and calculations in 1.29.3 to be submitted.)*

1.29.2 Documentation to be Submitted *(2002)*

The plans and details required for review and approval are as follows and are to be submitted as applicable to the particular design features and/or systems:

a ***Design and Operational Parameters***

Design pressures and depths

Design temperatures

Hydrostatic test pressures

Design sea state conditions

Maximum operating depth

Maximum mission time

Maximum number of occupants in each unit and/or system

Maximum weight of units including occupants, contents, entrapped water, etc.

b ***General***

General arrangement

Cross-section assembly

Outboard profile

Material specifications and grades, including tensile and impact values, for all pressure retaining or load bearing items

Dimensional details of pressure hull, pressure vessel(s) and scantlings

Weld details of pressure hull, pressure vessel(s) and scantlings

Welding procedures to include base and filler materials, pre and post weld heat treatment, tensile and impact values, extent of nondestructive testing.

Out-of-roundness tolerances

Fabrication tolerances

Dimensional details of penetrators, hatch details, hatch rings, lugs and any other internal or external connection to the hull

Penetrator sealing arrangements

Hatch sealing arrangements

Nameplate, including nameplate material and method of attachment

Plan showing all hull valves, fittings and penetrations

Exostructure details

Dimensional details of viewport components

Hard ballast tanks design details

Soft ballast tanks design details

Piping systems including pump capacities and pressure relief devices

Ballast piping systems

Layout of control stands

Equipment foundation and support arrangements with details where such foundations and supports increase stresses in the pressure hull or experience significant stress due to the operating loads encountered

Release devices and arrangement for jettisonable weights and equipment

Propeller details including shafting, bearings and seals

Propulsion motors, thrusters and wiring diagram

Steering control system

Electrical distribution system

Battery capacity, arrangement and main feeder scheme

Lifting and handling system

Depth indicating systems

Emergency systems

Fire fighting system

Details for permanently installed pressure vessels

Documentation for portable pressure vessels including standards of construction and design calculations for external pressure if units may at any time be subject to this condition.

List and location of implodable volumes

Materials and dimensions of umbilicals including cross sectional details

Any additional system deemed necessary to the intended operations

c ***Life Support Systems and Equipment***

Life support system details, both normal and emergency

Life support system capacities, fluids contained and supply arrangement

Specifications for environmental control systems and equipment including heating, gas analysis (CO_2, CO, CH_4, O_2, etc), absorption, circulation, temperature control, humidity control, equipment for tracing contaminants

Component list including manufacturer, model, design specifications and test documentation for all equipment used in the life support system

For gas analyzers: specifications of type of gas to be detected, principle of detection, range of pressures under which the instrument may be used

Lodging facilities and drainage systems in hyperbaric chambers

d ***Procedures***

Procedures for out-of-roundness and sphericity measurements

Cleaning procedures for breathing gas systems

Inclining experiment procedures

Functional test procedures

Sea trial procedures for normal and emergency condition tests

1.29.3 Calculations *(2002)*

The following calculations and analyses are to be submitted for review:

Pressure vessel stress analysis in compliance with Section 6

Foundation stress analysis

Pressure hull support reaction analysis

Analysis of lifting load and stresses induced in the hull

Window calculations in compliance with Section 7

Life support system analysis

Heat/cooling consumption for the hyperbaric chamber or underwater vehicle under the design conditions and the expected environmental temperatures

Electrical load analysis and loss of power, power sources; power demands

Short circuit current calculations

Coordination of short circuit protection devices (coordination study)

Calculation for the center of gravity and center of buoyancy

Intact stability analysis

Damage stability analysis

Hydrodynamic ascent calculations under normal and emergency conditions

1.33 Manuals

1.33.1 Operating Manual *(2002)*

(Text is added to 1.33.1 to read as follows:)

An operating manual describing normal and emergency operational procedures is to be provided and is to be submitted for review. The manual is to include the following as applicable.

System description

Operation check-off lists (list to include equipment requiring operational status verification or inspection prior to each dive/operation and verification of the existence of appropriately updated maintenance schedule—see 1.33.2)

Operational mission time and depth capabilities

Minimum electrical, life support and compressed air quantities required prior to commencing a dive

Sea state capabilities (see Table D.1)

Geographical dive site limitations as related to the design parameters addressed in 1.29 and 12.3

Special restrictions based on uniqueness of design and operating conditions

Life support system description including capacities

Electrical system description

Launch and recovery operation procedures

Liaison with support vessel

Emergency procedures, developed from systems analysis, for situations such as power failure, break in lifting cable, break in umbilical cord, deballasting/jettisoning, loss of communications, life support system malfunction, fire, entanglement, high hydrogen level, high oxygen level, internal and external oxygen leaks, stranded on bottom, minor flooding, and specific emergency conditions characteristic of special types of systems

Emergency rescue plan (see 8.11.1 and 12.37)

Color coding adopted

1.33.2 Maintenance Manual *(2002)*

(Text is removed from 1.33.2 to read as follows:)

A maintenance manual containing procedures for periodic inspection and preventive maintenance techniques is to be submitted for review. The manual is to include the expected service life of the pressure hull and of other vital components/equipment (e.g., viewports, batteries, etc.), methods for recharging life support, electrical, propulsion, ballast and control systems and specific instructions for the maintenance of items requiring special attention.

1.39 Personnel *(2002)*

(New subsection 1.39 is added and the current 1.39 and 1.41 are renumbered as 1.41 and 1.43.)

Underwater and related operations are a complex undertaking. In addition to the fitness represented by Classification as described in 1.5, appropriate personnel are of utmost importance to the successful and safe completion of a mission. Such issues fall under the purview of local jurisdictions, as noted in 1.37, and so are specifically not addressed by the Bureau.

Owners and operators of commercial and non-commercial units are ultimately responsible for, and are to assure themselves of, the competence of those performing activities related to the unit. Guidance may be obtained from the unit manufacturer, persons or entities believed by the owner/operator to be competent in the field and with the subject equipment, organizations such as the Association of Diving Contractors (ADC), publications such as the Guidelines for Design, Construction and Operation of Passenger Submersible Craft published by the International Maritime Organization (IMO) or from other sources as may be deemed appropriate by the owner/operator.

SECTION 2 DEFINITIONS

2.61 Light Ship *(2002)*

(The new subsection is to be added at the end of Section 2.)

The condition in which a vessel is complete in all respects, but without consumables, stores, cargo, crew and passengers, if applicable, and their effects, and without any liquids on board except that machinery fluids, such as lubricants and hydraulics, are at operating levels.

2.63 Fire-restricting Materials *(2002)*

(The new subsection is to be added at the end of Section 2.)

Fire-restricting materials are those materials having properties complying with IMO Resolution MSC.40(64); this resolution provides standards for qualifying marine materials as fire-restricting materials. Fire-restricting materials should: have low flame spread characteristics; limit heat flux, due regard being paid to the risk of ignition of furnishings in the compartment; limit rate of heat release, due regard being paid to the risk of spread of fire to any adjacent compartment(s); and limit the emission of gas and smoke to quantities not dangerous to the occupants.

SECTION 3 GENERAL REQUIREMENTS AND SAFEGUARDS

(Titles and text of existing paragraphs 3.1.3 and 3.1.4 revised as follows:)

3.1 Nonmetallic Materials

3.1.3 Internal Materials *(2002)*

Linings, deck coverings, ceilings, insulation, partial bulkheads and seating are to be constructed of materials that are fire-restricting under the anticipated environmental conditions.

3.1.4 External Materials *(2002)*

Decks, deck coverings, skins and fairings are to be of materials that will not readily ignite or give rise to toxic or explosive hazards at elevated temperatures.

3.3 Fire Fighting

(Existing paragraphs 3.3.1 and 3.3.2 are revised as indicated, new paragraph 3.3.3 is added and current paragraph 3.3.3 is renumbered 3.3.4.)

3.3.1 General *(2002)*

All units are to be provided with fire detection, alarm and extinguishing systems. For compartments always occupied by alert persons during operation, the occupants may comprise the fire detection and alarm system provided such occupants possess a normal sense of smell. Salt water is not to be used as an extinguishing agent. Propellants of extinguishing mediums are to be nontoxic. Consideration is to be given to the increase in compartment pressure resulting from use of extinguishers. See also 8.7.3b.

3.3.2 Fixed Systems *(2002)*

When units are provided with a fixed fire-extinguishing system using a gaseous medium suitable for manned spaces, the system is to be designed to evenly distribute the extinguishing medium throughout each compartment of the pressure boundary. Capacity of the system is to be such that a complete discharge of the extinguishing medium will not result in a toxic concentration.

3.3.3 Portable Systems *(2002)*

When units are not provided with a fire-extinguishing system per 3.3.2, the fire extinguishing means is to consist of portable extinguishers using distilled water or another non-conductive liquid agent, dry chemical or a gaseous medium suitable for use in manned spaces. The capacity of a portable extinguishing system using a gaseous medium is to be such that complete discharge of the extinguishers will not result in a toxic concentration.

3.7 Emergency Locating Devices *(2002)*

(Existing subsection 3.7 is split into two paragraphs and revised as shown. A new paragraph is added at the end of the revised subsection 3.7.)

A surface locating device, such as a strobe light or VHF radio, and a subsurface locating device, such as an acoustic pinger, sonar reflector or buoy, are to be provided. Surface detectors or other equipment as required for the detection of subsurface locating devices is to be available.

Diving bells and other similar tethered units may have an emergency locating device designed to operate in accordance with paragraph 2.12.5 of IMO Resolution A.536(13) “Code of Safety for Diving Systems” as amended by Resolution A.583(14). (See Appendix 2.)

Electric locating devices not designed and equipped to operate using a self-contained power source are to be arranged to be powered by both the normal and the emergency power supplies. Non-electric locating devices are to be deployable without electric power.

3.9 Surface Anchoring, Mooring and Towing Equipment *(2002)*

(The following text, taken from subsection 12.5, is revised as shown. Current subsection 3.9 and following are renumbered as required.)

An accessible towing point, appropriately sized for the anticipated conditions, is to be provided. When anchoring and mooring equipment is carried on the submersible, the number, weight, strength and size of anchors, chains and cables are to be appropriately sized for the anticipated conditions.

3.11 Proof Testing *(2002)*

(The title of existing subsection 3.11 is revised; the subsection is split into numbered and titled paragraphs and revised as indicated. Some sentences are editorially revised.)

3.11.1 Hydrostatic Test

After out-of-roundness measurements have been taken, all externally-pressurized pressure hulls are to be externally hydrostatically proof tested in the presence of the Surveyor to a pressure equivalent to a depth of 1.25 times the design depth for two cycles. Pressure hulls designed for both internal and external pressure are also to be subjected to an internal hydrostatic pressure test in accordance with Part 4, Chapter 4 of the *Rules for Building and Classing Steel Vessels*. Acrylic components are to be tested in accordance with Section 7 of these Rules.

3.11.2 Strain Gauging

During the external proof testing in 3.11.1, triaxial strain gauges are to be fitted in way of hard spots and discontinuities. The location of strain gauges and the maximum values of stress permitted by the design at each location are to be submitted for approval prior to testing.

3.11.3 Waiver of Strain Gauging

Hydrostatic testing without strain gauges will be acceptable for units that are duplicates of a previously tested unit and have a design depth not greater than the tested unit. Units designed and built in accordance with the requirements of Section VIII Division 1 of the ASME Boiler and Pressure Vessel Code or other recognized code having an equal or higher design margin (factor of safety) may be accepted without strain gauging. (This does not preclude the use of design standards having a lower design margin. See also 3.11.5 and 6.1 of these Rules.)

3.11.4 Post Test Examination

Following testing, all pressure boundary welds are to be examined in accordance with the requirements for magnetic particle, liquid penetrant or eddy current testing in accordance with Section 5, and out-of-roundness and sphericity measurements are to be taken. Acceptance criteria are to be in accordance with Section 5.

3.11.5 Alternative Test Procedures

When the pressure boundary is designed in accordance with an acceptable standard other than Section 6 of these Rules, hydrostatic testing may be conducted in accordance with the requirements of that standard. Such units are to be tested for two cycles in the presence of the Surveyor. Strain gauging is to be in accordance with 3.11.2 and 3.11.3. Post test examination is to be in accordance with 3.11.4 except that the acceptance criteria are to be in accordance with the standard used.

3.19 Buoyancy, Emergency Ascent and Stability

3.19.1 Submersibles and Other Untethered Units *(2002)*

*(The first two paragraphs of 3.19.1 are converted to subparagraphs **a** and **c** addressing normal and emergency conditions respectively; the other subparagraphs are renumbered as required. Paragraph 3.19.1 is revised as follows.)*

a ***Normal Ballast System*:** Each manned unit is to be fitted with a ballast system capable of providing normal ascent and descent and necessary trim adjustments. Ballast tanks that are subjected to internal or external pressure are to comply with the requirements of Section 6. Two independent means of deballasting are to be provided; one is to be operable with no electric power available.

b ***Depth Keeping Capability*:** Submersibles are to be capable of remaining at a fixed depth within any operational depth and within all normal operating conditions.

c ***Emergency Surfacing System*:** In addition to the normal ballast system, an emergency surfacing system is to be provided. This system is to provide positive buoyancy sufficient to safely evacuate all occupants, is to require at least two positive manual actions for operation and is to be independent of electric power. The emergency surfacing system is to operate properly under all anticipated conditions of heel and trim and is to comply with one of the following:

1 The system is to jettison sufficient mass so that if the largest single floodable volume, other than the personnel compartment, is flooded, the ascent rate will be equal to the normal ascent rate. The released mass may consist of a drop weight, appendages subject to entanglement, or a combination of both.

2 The personnel compartment may be provided with a means of separating it from all other parts of the system, including appendages, provided the personnel compartment is positively buoyant and meets the stability criteria of **f** below when released.

d ***Intact Surface Stability:*** Each unit is to have sufficient intact stability on the surface so that in the worst loading condition, when subjected to a roll expected under the worst conditions listed in Table D.1 for the design sea state, the unit will not take on water through any hatch that may be opened when surfaced. In addition, the distance from the waterline to the top of coamings around hatches that may be opened with the unit afloat is not to be less than 2.5 ft. with the unit upright.

e ***Underwater Operation:*** Adequate static and dynamic stability in submerged conditions is to be demonstrated by the tests and calculations required in 3.13 and item **g** below. For all normal operational conditions of loading and ballast, the center of buoyancy is to be above the center of gravity by a distance *GB*, which is the greater of either 51 mm (2 in) or the height as determined below:

$$GB_{\min} = nwNd / W \tan\alpha$$

where

n	=	0.1 (This represents 10 percent of the people aboard moving simultaneously.)
w	=	175 pounds (79.5 kg) per person (for passenger submersibles, w may be taken as 160 lbs (72.5 kg) per person)
d	=	the interior length of the main cabin accessible to personnel mm (in) (This should not include machinery compartments if they are separated from the main cabin with a bulkhead.)
N	=	total number of people onboard the submersible
W	=	the total weight (in units consistent with w) of the fully loaded submersible, not including soft ballast

α = 25 degrees (This represents the maximum safe trim angle. A smaller angle may be required if battery spillage or malfunction of essential equipment would occur at 25 degrees. This assumes that each person has an individual seat that is contoured or upholstered so that a person can remain in it at this angle.)

f ***Emergency and Damaged Condition:*** Submersible units are to have adequate stability under any possible combination of dropped jettisoned masses. Under some emergency conditions, the distance between the center of buoyancy and center of gravity may be reduced, but in no case is it to be less than one-half of that required in **e** above. Inverted surfacing is not permitted.

g ***Calculations and Experiments:*** The following calculations are to be submitted and tests are to be witnessed by the Surveyor:

1 *Detailed Weight Calculations:* Calculations are to be provided and are to include calculated positions of center of buoyancy (*CB*), center of gravity (*CG*), total weight of the submarine (*W*) and displacement (*DELTA*). This can be achieved by maintaining a detailed spreadsheet during design and construction.

2 *Hydrostatic Model:* A mathematical model is to be used to calculate *DELTA*, the positions of the center of buoyancy (*CB*), and the metacenter (*CM*), by computing the hydrostatic properties during design.

3 *Deadweight Survey and Lightship Measurement:* The location, number and size of all items listed on the spreadsheet are to be physically checked after construction and outfitting. The completed submersible is to be weighed with a scale and the measured weight is then to be compared to the total spreadsheet weight, compensating for any extraneous weights that were onboard the submersible at the time of testing.

4 *Inclining Experiments:* The completed submersible is to be inclined on the surface and submerged in order to fix *GB* (the distance between *CC* and *CB*) and *GM* (the distance between *CC* and the metacenter *CM*). Guidance for design and performance of inclining experiments may be obtained from ASTM F 1321 and Enclosure (2) to the Navigation and Vessel Inspection Circular No. 5-93 (NVIC 5-93). Such testing is not required for units that are duplicates of a previously tested unit.

5 *Scenario Curves:* *CB*, *CG*, *W*, *CM*, and *DELTA* are to be assembled in graphic form for interpretation and comparison with criteria.

SECTION 5 FABRICATION

5.9 Welding of Non-Ferrous Materials *(2002)*

*(Paragraph 5.5.6 becomes subsection 5.5; the remainder of subsection 5.5 becomes 5.7 and is re-titled "Welding of Ferrous Materials". Subsection 5.9 is added and following subsections are renumbered as necessary. Current 6.15.3 becomes a portion of subparagraph **b**.)*

5.9.1

Welding of non-ferrous material will be subject to special consideration.

5.9.2 Welded Joints in Aluminum

a ***Alloys listed in 4.3b:*** The ultimate and yield strengths for welded aluminum alloys listed in 4.3b, other than 6061-T6, are to be taken from Table 30.1 of the *Rules for Building and Classing Aluminum Vessels*.

b ***Alloy 6061-T6:*** The ultimate strength of welded 6061-T6 aluminum is to be no greater than 16.9 kg/mm^2 (24,000 psi) and the yield strength is to be no greater than 6.3 kg/mm^2 (9,000 psi).

c ***Other Alloys and Tempers:*** Tensile and yield strengths for welded aluminum alloys and/or tempers not listed in 4.3b, where such use is permitted, are to be obtained from recognized references or approved test results.

SECTION 6 METALLIC PRESSURE BOUNDARY COMPONENTS

6.9 Fatigue *(2002)*

(New sentence added at end of present 6.9.)

A fatigue analysis is to be submitted when it is anticipated that the life time full range pressure cycles N will exceed that obtained from the following equation:

$$N = [1160(3000 - T)/(Kf_\tau - 14500)]^2$$

where … *(unchanged)*

Pressure cycles of less than full pressure are to be included in N in the ratio p/P where p is the actual pressure of the cycle under consideration and P is the design pressure.

6.11 Drainage *(2002)*

(New second paragraph added to 6.11.)

Drainage openings are to be provided at points where liquid may accumulate.

Alternatively, fillers may be used to occupy the volume in which liquid could accumulate provided the fillers remain flexible, are adhered to the substrate per the manufacturer’s instructions and field inspection procedures are included in the maintenance manual. Inspection procedures must permit detection of corrosion under the filler without removal of the filler or must require that the filler be removed and replaced, per the manufacturer’s instructions, at each inspection.

SECTION 7 WINDOWS AND VIEWPORTS

7.3 Definitions *(2002)*

(Subsection 7.3 is added and the current 7.3 through 7.21 are renumbered accordingly.)

7.3.1 Design Life

The Design Life of an acrylic window is the length of time defined by Section 2-2.7 of ASME PVHO-1 for an acrylic window of a particular geometry and meeting the requirements of the PVHO-1 standard.

7.3.2 Service Environment

An acrylic window's Service Environment is that set of environmental conditions to which the subject window has been exposed during its Service Life. Factors such as exposure to weathering, sunlight and UV radiation, and other particulars that may affect the rate of material degradation, are included in Service Environment.

7.3.3 Service Life

The Service Life of an acrylic window is the maximum length of time that an acrylic window may be used in a pressure vessel for human occupancy.

7.3.4 Viewport Assembly

A viewport assembly is a pressure vessel penetration consisting of a window, flange, retaining rings, retaining ring fasteners and seals.

7.3.5 Window

A window is the transparent, impermeable, and pressure resistant insert in a viewport.

7.5 Design Parameters and Operating Conditions *(2002)*

*(The first paragraph is editorially revised to the current edition of ASME PVHO-1 and subparagraph **f** is added. Current subparagraph **f** is renumbered **g**.)*

The windows of underwater vehicles and hyperbaric installations are subject to the design parameters contained in the latest edition of ASME PVHO-1. The design parameters below, as well as those presented in Appendix 1, are based on ASME PVHO-1a-1997. It is the responsibility of the designer to determine that these requirements are consistent with the latest edition of the ASME PVHO-1 safety standard.

a The operating temperature is to be within the 0°F (-18°C) to 150°F (66°C) range.

b The pressurization or depressurization rate is to be less than 145 psi/s (10 bar/s).

c The contained fluid (external or internal) is to be only water, seawater, air, or breathing gases.

d The number or the total duration of pressure cycles during the operational life of the windows is not to exceed 10,000 cycles or 40,000 hours, respectively.

e The maximum operational pressure is not to exceed 20,000 psi (1380 bar)

f The exposure to nuclear radiation shall not exceed 4 megarads

g The design life of the windows is to be in accordance with the following:

1 Not to exceed 20 years for windows that are exposed only to compressive stresses

2 Not to exceed 10 years for all windows subject to tensile stresses

The design life of a window is counted from the date of fabrication, regardless of the effective length of time during which the window has been used.

Design parameters different from the above will be subject to special consideration.

7.7 Certification *(2002)*

(Text is revised as follows.)

Copies of the following certifications are to be submitted for each window:

7.7.1 Design Certification

A design certification is to be provided for each window and viewport assembly design. This document is to certify that the design complies with ASME PVHO-1. The certificate is to include the information required by Enclosure 1 in Appendix A of ASME PVHO-1 and may take the form of that enclosure.

7.7.2 Material Manufacturer's Certification

The manufacturer of the acrylic material is to provide a document certifying that the material complies with ASME PVHO-1. The Acrylic material is to be marked so as to be traceable to this certificate. The certificate is to include the information required by Enclosure 2 in Appendix A of ASME PVHO-1 and may take the form of that enclosure.

7.7.3 Material Testing Certification

After annealing, material acceptance tests are to be performed by the material manufacturer or by an independent testing laboratory. The material acceptance tests are to be documented by a certificate that includes the information required by Enclosure 3 in Appendix A of ASME PVHO-1. The certificate may take the form of PVHO Enclosure 3.

7.7.4 Pressure Testing Certification

Window pressure testing in accordance with 7.19 is to be documented by a certificate. The certificate is to include the information required by Enclosure 4 in Appendix A of ASME PVHO-1 and may take the form of that enclosure.

7.7.5 Fabrication Certification

The window fabricator is to provide an overall window certification confirming that the window was fabricated in compliance with these Rules and ASME PVHO-1. The certificate is to provide traceability of the window through all stages of manufacture and fabrication and is to include the information required by Form PVHO-2 of ASME PVHO-1. Form PVHO-2, Form PVHO Case 5, or a similar form may be accepted.

7.17 Pressure Testing

(A new paragraph 7.17.8 is added at the end of present subsection 7.17.)

7.17.8 *(2002)*

A hydrostatic or pneumatic test at less than design temperature may be substituted for the tests specified in 7.17.2 and 7.17.3. During the hydrostatic or pneumatic test, the pressure shall be maintained for a minimum of 1, but not more than 4, hours. The test pressure shall exceed the design pressure, but shall not exceed 1.5 times the design pressure or 20,000 psi (138 MPa), whichever is the lesser value. The temperature of the pressurizing medium during the test shall be 25°F to 35°F (14°C to 20°C) below the design temperature of the window, except for 50°F (10°C) design temperature windows, where the temperature during the test shall be in the 32°F to 40°F (0°C to 4°C) range. All the other requirements of the mandatory pressure test specified in paragraphs 7.17.4, 7.17.5 and 7.17.6 remain applicable.

SECTION 8 LIFE SUPPORT AND ENVIRONMENTAL CONTROL SYSTEMS

8.7 Fresh Air *(2002)*

8.7.22

*(Subparagraph **b** is revised, subparagraph **c** is added and existing subparagraph **c** becomes **d**.)*

a Ventilation of a vehicle on the surface may be achieved via an air duct arranged to prevent admission of spray water.

b When the battery compartment is located inside the vehicle, a fan or similar device is to be provided for positive ventilation of the compartment during charging and for suitable time before and after charging. Fans are to be of non-sparking construction and the ventilation system is to provide thirty (30) air changes per hour. The venting of the battery compartment is to be separated from any other ventilation system. If the fan becomes inoperable, then charging of the batteries is to be automatically discontinued.

c Battery compartments located inside the vehicle and containing batteries charged by a device having an output of 200 watts or less, arranged so as to prevent driving the batteries to their gassing potential, may be provided with natural ventilation provided the ventilation opening(s) are located at the highest point(s) in the compartment and have an aggregate area equal to the volume of the compartment divided by 30 inches.

d Habitats and working chambers etc., are to be provided with means to remove, prior to a mission, any potentially explosive or toxic gas mixtures which may develop.

8.9 Distribution Piping

8.9.3 Valves *(2002)*

(Current subparagraph 8.9.3b is revised as follows:)

b Control valves used in oxygen systems operating at pressures exceeding 125 psig are to be of the slow-opening type, such as needle valves.

8.9.4 Supply Piping *(2002)*

*(Created new 8.9.4 as follows. A portion of current subparagraph 8.7.1b is revised, as shown in **a**; **c** is taken from 8.9.1; subparagraph 8.9.3d is moved to 8.9.4d; and subparagraph **b** is added.)*

a Each independent gas supply line is to be equipped with a supply pressure gauge and a shut-off valve downstream of the supply pressure gauge connection. A block valve, located such that it is capable of being monitored during operation, is to be installed between the supply line and the supply pressure gauge to permit isolating the pressure gauge.

b The shut-off valve on a gas supply line must be accessible and is to be located such that release of the volume contained in the downstream piping will not increase the internal pressure more than 1 atm.

c Supply lines are to be secured in place to prevent movement.

d Suitable relief valves are to be provided if malfunctioning of a system will expose flow indicators to pressures above their design pressure. Shut-off valves are to be provided to isolate relief valves.

8.9.5 Supply External to the Main Hull for Untethered Units *(2002)*

(The current 8.9.4 is renumbered as 8.9.5. The existing 8.9.5 becomes 8.9.7. The current text is revised as follows:)

When pressure containers for oxygen supply are stored outside the pressure hull there are to be at least two banks with separate penetrations entering the craft. These penetrations should be positioned such as to minimize the possibility that a single incident would cause failure of both penetrators.

8.9.6 Pressurized Oxygen Supply Piping *(2002)*

(New paragraph 8.9.6 is added before current renumbered paragraph 8.9.7.)

a The shut-off valve on an oxygen supply line must be accessible and is to be located such that release of the volume contained in the downstream piping will not cause the oxygen concentration to exceed the maximum permitted in 8.21.1. Oxygen supply piping is to meet the requirements of 8.15.4.

b Both lubricants and sealants used in potentially pressurized oxygen piping systems are to be compatible with oxygen at the maximum system supply pressure.

8.11 Reserve Life Support Capacity *(2002)*

(New subsection 8.11 is added and subsequent subsections are renumbered. The new 8.11.1 and 8.11.2 replace 8.21.3a and 8.21.3b.)

At the commencement of a dive, the breathing gas supply and CO_2 removal systems are to have sufficient capacity for the anticipated mission time, plus a reserve capacity as required below. The breathing gas supply system reserve time is to be based on the requirements in 8.7; the CO_2 removal system reserve time is to be based on the requirements in 8.9.

8.11.1 Untethered Units

Each submersible or other untethered unit is to have a minimum reserve capacity consistent with the emergency rescue plan, but not less than 72 hours.

8.11.2 Tethered Units

Tethered units which carry their own normal breathing gas supply are to be provided with a reserve breathing gas supply sufficient for the design mission time, plus a minimum of ten percent of the design mission time but not less than an eight hour reserve.

SECTION 10 MECHANICAL EQUIPMENT

10.5 Pressure Vessels, Heat Exchangers and Heaters

10.5.1 General *(2002)*

*(Paragraph 10.5.1 is split into subparagraphs **a** through **d** and the text in subparagraph **e** is added.)*

a Plans, calculations and data for all pressure vessels, heat exchangers, and heaters are to be submitted for review and approval in accordance with 1.29 and 1.31 of these Rules. They are to be constructed, installed, inspected and tested in the presence and to the satisfaction of the Surveyor in accordance with approved plans. All pressure vessels, heat exchangers and heaters are to be protected by a suitably sized safety relief valve.

b All pressure vessels, heat exchangers and heaters are to comply with the requirements applicable to Group I pressure vessels in Section 4-4-1 of the *Rules for Building and Classing Steel Vessels*.

c Mass produced pressure vessels may be accepted in accordance with 4-4-1/1.11.2 of the *Rules for Building and Classing Steel Vessels*.

d Seamless pressure vessels for gasses may be accepted in accordance with 4-4-1/1.11.4 of the *Rules for Building and Classing Steel Vessels* provided their application does not violate any restrictions contained in the standard applied.

e Fiber reinforced plastic (FRP) pressure vessels may be accepted on a case-by-case basis.

10.5.2 Pressure Vessels Subject to External Pressure *(2002)*

*(Paragraph 10.5.2 is split into subparagraphs **a** and **b** and the text in subparagraphs **c** and **d** are added.)*

a Pressure vessels, heat exchangers and heaters subject to external pressure are to comply with Sections 4, 5 and 6 of these Rules and are to be tested in accordance with 3.11 in the presence and to the satisfaction of the Surveyor.

b As an alternative to the design requirements of **a** above, pressure vessels, heat exchangers and heaters subject to external pressure are to comply with the appropriate external pressure requirements in the codes or standards acceptable for Group I pressure vessels in Section 4-4-1 of the *Rules for Building and Classing Steel Vessels*.

c Fiber reinforced plastic (FRP) pressure vessels are to be hydrostatically tested in accordance with 3.11.1 in the presence and to the satisfaction of the Surveyor.

d Unreinforced plastic pressure vessels may be accepted for service at a maximum external pressure of 70 psig (157 fsw) based on a one-cycle hydrostatic test, per the requirements below, of a prototype vessel. Such pressure vessels are to be hydrostatically tested in accordance with 3.11.1 in the presence of and to the satisfaction of the Surveyor, and are to be constructed, installed and inspected to the satisfaction of the Surveyor in accordance with approved plans.

1 A test pressure vessel is to be constructed per the drawings, except that the worst-case dimensional tolerances are to be met.

2 Deviations from circularity of the test pressure vessel are to be measured and recorded in the presence and to the satisfaction of the Surveyor. These measurements are to be submitted to the technical office for review. Upon approval of the vessel design, these measurements will become the maximum permitted deviation of the production pressure vessels.

3 The test pressure vessel is to be fitted with a sensor acceptable to the Surveyor and arranged to detect initiation of leakage.

4 The test pressure vessel is to be externally pressurized, in the presence and to the satisfaction of the Surveyor, to collapse or first detection of leakage. The external test pressure is to be recorded on a chart recorder and the pressure at failure is to be marked on the chart.

5 After pressure testing, the test pressure vessel material is to be tested, to the satisfaction of the Surveyor, to determine the actual modulus of elasticity of the test vessel material. At least four material test coupons, taken from different areas of the test vessel, are to be tested.

6 The external pressure at failure is to be corrected for the minimum specified modulus of elasticity of the pressure vessel material versus the measured modulus of elasticity of the test vessel material, as follows:

$$P_{vf} = P_t \frac{E_s}{E_m}$$

where

P_{vf} = vessel failure pressure

P_t = actual test pressure at failure

E_s = minimum specified modulus of elasticity of the pressure vessel material

E_m = measured modulus of elasticity of the test vessel material

7 The test procedure and test results, along with the measurements taken in 2 above, are to be submitted to the technical office for review. The minimum vessel failure pressure, P_{vf}, obtained in the above test must be at least 5 times the pressure vessel's external design pressure.

10. 7 Piping Systems *(2002)*

10.7.7

Pipe sections are to be joined by full penetration welds. Flange connections may be accepted provided they comply with a recognized standard. Butt weld flanges are to be used except that socket weld flanges may be used up to the equivalent of 3-inch NPS and for non-essential services. Special consideration will be given to other pipe connections.

SECTION 11 ELECTRICAL INSTALLATIONS

11.5 Power

11.5.1 Main and Emergency Power *(2002)*

The electrical installations essential to the safe completion of the mission are to be supplied from independent main and emergency sources of electrical power. The emergency source of electrical power is to be available in not more than 45 seconds after interruption of the main power source. The main power source for all units is to have sufficient capacity for the design mission. In addition, for untethered units, prior to commencing any dive, the main power source is to have a reserve capacity sufficient to operate the following systems for the duration required in 8.11 or 12.27, as applicable to the subject unit:

- **a** Emergency internal lighting
- **b** Communication equipment
- **c** Life support systems
- **d** Environmental monitoring equipment
- **e** Essential control systems
- **f** Other equipment necessary to sustain life

11.11 Batteries

(Added title to 11.11.2 and revised text to read as follows:)

11.11.2 Terminal Potting *(2002)*

Cell top terminal potting, if used, is to possess good dielectric properties and is not to absorb electrolyte, oil or water at design operating pressures. A dry insulation resistance measurement is to be made by means of a 500-volt DC insulation resistance test instrument (megger) between the leads and the insulated casing and is to show a reading of at least 50 megohms.

11.13 Motors

(Added titles to 11.13.1 and 11.13.2 and revised text to read as follows:)

11.13.1 Propulsion Motors Not Subject to Pressure *(2002)*

Propulsion motors inside a pressure boundary of submersible units are to be suitable for marine atmosphere, anticipated operating temperatures and shock loading.

11.13.2 Propulsion Motors Subject to Pressure *(2002)*

Propulsion motors subject to operational pressure, are to be designed with due considerations to the consequences of environmental corrosion and pressure, temperature and shock loading.

Test data or satisfactory service experience demonstrating adequacy for intended service are to be used to substantiate the design. When pressure compensators are used, they are to be supported by complete design and detail plans and calculations. When the adequacy of pressure compensators is predicated on the complete removal of air inside the housing, the contemplated air purging procedure is to be included in the operations manual.

11.15 Distribution and Circuit Protection

(Added titles to 11.15.3, 11.15.4 and 11.15.6 and revised text to read as follows:)

11.15.3 Pressure Boundary Power Penetrations *(2002)*

Both positive and negative conductors from the main and auxiliary power sources are not to pass through the same penetrator or connection in a pressure boundary and are to be spaced sufficiently to prevent damaging currents. All power leads passing through a pressure boundary are to be adequately protected by circuit breakers or fuses against overload and short circuit. The circuit breakers or fuses are to be located on the power source side of the pressure boundary and are to have the ability to open the circuit quickly to prevent damage to the watertight integrity of the electrical penetration. Tests may be required to demonstrate the ability of the device to perform as mentioned above.

11.15.4 Distribution Panels *(2002)*

All distribution panels are to be accessible during operation. It is to be possible to disconnect power to each chamber separately.

11.15.6 Separation of Cables and Wiring *(2002)*

*(Text in **b** is added to current paragraph 11.15.6 as indicated below.)*

a Cables and wiring of circuits supplied by different voltages and by the main and emergency circuits are to be effectively separated from each other. Electric plugs, sockets and receptacles are to be of a type which prevent improper inter-connections of the various systems and are to be provided with a means of securing after connection is made. The use of a color coding for the various systems is recommended.

b Intrinsically safe wiring is to be separated from non-intrinsically safe wiring by at least 50 mm (2 in) and in accordance with the equipment manufacturer's recommendations. Other suitable standards may be acceptable.

11.17 Distribution Cables, Wiring and Penetrators

(Added title to 11.17.8 and revised text to read as follows:)

11.17.8 Testing of Gland Type Penetrators *(2002)*

Samples of gland type penetrators (those for which the electrical cable forms part of the pressure boundary) used for electrical service are to be tested by the manufacturer, as indicated below, in the listed sequence of tests. Penetrators are to be tested assembled, with a length of cable of the type that will be used in the installation. The cable and penetrator assemblies are to show no sign of deficiency during and after the testing.

a Voltage test by applying 1 kV plus twice the design voltage for 1 minute to each conductor and armor separately under the most unfavorable environmental condition they will be subjected to during service.

b Hydrostatic test to a pressure of 1.5 times the design pressure repeated six times. The pressure is to be applied to the side that will be under pressure in the actual application and is to be maintained for 20 minutes after the last cycle.

c Gas leakage test with cable cut open using air to twice the design pressure or helium to 1.5 times the design pressure.

d Insulation test to 5 megohms at design pressure applying salt water. Tests are to be made between each conductor and armor.

Novel designs that have not been substantiated by service experience or acceptable test data for the operating depth will require full scale strength and cycling testing to at least 2.5 times the operating depth.

11.17.9 Testing of Pin Type Penetrators *(2002)*

(New paragraph 11.17.9 is added as shown below:)

Samples of pin type penetrators (those for which the electrical cable does not form part of the pressure boundary) used for electrical service are to be tested by the manufacturer as indicated below, in the listed sequence of tests. The penetrator assemblies are to show no sign of deficiency during and after the testing.

a Voltage test by separately applying 1 kV plus twice the design voltage for 1 minute across each conductor pin and the penetrator body under the most unfavorable environmental condition they will be subjected to during service.

b Hydrostatic test to a pressure of 1.5 times the design pressure repeated six times. The pressure is to be applied to the side that will be under pressure in the actual application and is to be maintained for 20 minutes after the last cycle.

c Gas leakage test using air to twice the design pressure or helium to 1.5 times the design pressure.

d Insulation test to 5 megohms at design pressure applying salt water. Tests are to be made between each conductor pin and the penetrator body.

In cases where it is not clear that the method of attachment of the conductors will not compromise the penetrator pin sealing arrangement, the Technical Office may require the attachment of a short piece of conductor to each pin, prior to testing.

Novel designs that have not been substantiated by service experience or acceptable test data for the operating depth will require full scale strength and cycling testing to at least 2.5 times the operating depth.

SECTION 12 ADDITIONAL REQUIREMENTS FOR SUBMERSIBLES INTENDED FOR TRANSPORTATION OF PASSENGERS

12.3 Operational Restrictions and Safeguards *(2002)*

(Paragraphs 12.3.1 and 12.3.2 revised to read as follows:)

12.3.1

Classification of passenger submersibles is issued for operation in waters with a sea-bed depth not greater than 105 percent of the rated depth of the unit, within the design parameters in subsection 1.29 and paragraph 12.3.2 and under the supervision of dedicated surface support during missions.

Passenger submersibles are to be operated only in areas surveyed in accordance with paragraph 12.5.1.

12.3.2

In addition to the required plans, calculations and data in 1.29 of the Rules, the designer of the submersible is to submit the following operational parameters as a basis for design review and classification:

a Maximum current

b Night/limited visibility operation

c Number of passengers/crew

d Maximum towing speed/towing line tension

e Maximum speed while surfaced and submerged

f List of hazards to be avoided

(Title and text of Subsection 12.5 revised to read as follows:)

12.5 Dive Sites *(2002)*

Dive sites for passenger submersibles are to be investigated by the operator for operational hazards prior to diving. Results of this investigation are to be documented and provided to the pilot prior to diving.

12.27

12.27.2 Fire Extinguishing System *(2002)*

(The existing 12.25 is renumbered as 12.27.1. The text below is revised from existing 12.27.)

Each compartment in the main hull is to be provided with a suitable fire extinguishing system. This may include portable extinguishers. Capacity calculations for all systems are to be submitted for review. See also 3.3.

Chemical extinguishing agents or propellants with toxic or narcotic effects for any operating condition are not permitted. Choking hazards of extinguishing agents are to be taken into consideration.

(New paragraph 12.27.3 is added as shown below:)

12.27.3 Passenger Protection *(2002)*

For submersibles demonstrating compliance with the requirements below, the emergency life support system required in 8.21 may be replaced by individual devices, one per passenger, that provide protection from inhalation of hazardous products of combustion including carbon monoxide (CO). Protective devices intended for such use are to be submitted for review; device approval is on a case-by-case basis. Crewmembers' emergency life support is to meet the requirements in 8.21.

a The submersibles must be able to surface from rated depth and have the hatch(es) opened within a time period such that the oxygen level within the passenger compartment does not fall below 18 volume percent with full occupancy.

b The time period described in **a** above is not to exceed 15 minutes.

12.29 Acrylic Window Protection *(2002)*

(Text revised to read as follows:)

A transparent, shatterproof protective screen is to be provided on the interior of all windows normally accessible to passengers. Where this is not possible, precautions are to be taken to prevent passengers from causing physical damage to the windows.

12.37 Reserve Life Support *(2002)*

(New subsection 12.37 is added as follows:)

Reserve life support is to be in accordance with 8.11, except that the minimum reserve in 8.11.1 may be reduced to a minimum reserve of 24 hours for units complying with this section and meeting the following requirements:

a The submersible is used at a site meeting the requirements of 12.5 and, if there are multiple dive sites, the site selected for each dive is recorded in a shore-based log prior to the dive. The maximum bottom depth at the site must not exceed the depth that can be safely reached by SCUBA divers. In addition, maximum depth may be limited per item **g** below or by emergency procedures in the Operations Manual (see 1.33.1).

b The unit's surface support vessel can be reached by shore-based divers within one hour.

c The submersible is equipped with **two** separate ballast systems and a jettisonable weight.

d At least one of the ballast systems in **c** above is designed such that divers may manually blow a sufficient number of tanks to achieve positive buoyancy sufficient to safely evacuate passengers and crew as specified in the dive plan.

e Design features and/or procedures intended to implement items **a** through **d** above are to be submitted to the Technical Office for approval prior to implementation of a minimum reserve capacity less than that specified in 8.11.1.

f Prior to approval of the design features and/or procedures referenced in **e** above, performance of a simulated rescue may be required at the discretion of the Technical Office or the attending Surveyor. This test may be conducted at a depth less than the design depth.

g This provision requires preparation and maintenance of a dive plan, including a decompression schedule, for use in the event of an emergency. The dive plan is to consider the emergency procedures included in the Operations Manual (see **a** above) and be appropriate for the worst-case conditions at the dive site in which the submersible will be operated. The plan is to include the number of divers required, their qualifications and certifications and the required equipment. Rescue drills are to be performed on a suitable schedule to insure that a realistic estimate of bottom time is used in the plan.

h A life support duration less than that required in 8.11.1 is to be documented in the *Record*.

APPENDIX C CERTIFICATION OF CHAMBERS, DIVER TRAINING CENTERS AND DIVE SIMULATORS

C.27 Materials

C.27. 2 Internal Materials

(Add new text in second paragraph as follows:)

Materials and equipment inside manned compartments are to be such that they will not give off noxious or toxic fumes within the limits of anticipated environments or under fire conditions. Where compliance with this requirement has not been demonstrated through satisfactory service experience, a suitable analysis or testing program is to be performed or submitted. Systems are to be designed and equipped to minimize sources of ignition and combustible materials.

Linings, deck coverings, ceilings, insulation, partial bulkheads, seating and bedding are to be constructed of materials that are fire-restricting under the anticipated environmental conditions.

C.37 Communication *(2002)*

(Subsection C.37 is revised as follows:)

a A two-way sound-powered communication system is to be provided for each compartment. The system is to provide communication capability between the occupants and the outside monitor in the dive control station.

b Speech unscramblers are to be provided when mixed gas is used.

c Any non-sound-powered communication systems are to be supplied by two independent sources of power.

APPENDIX D CERTIFICATION OF HANDLING SYSTEMS

D.3 Definitions

D.3.1 Handling System (Launch and Recovery System) *(2002)*

(Revised text as follows:)

A system supporting launch, recovery and other handling operations of underwater units, hyperbaric facilities and their ancillary equipment and may include cranes, booms, masts, frames, davits, foundations, winches and associated hydraulic and electrical systems as necessary for the intended operations.