

**ASME PVHO-1-2019**  
(Revision of ASME PVHO-1-2016)

# **Safety Standard for Pressure Vessels for Human Occupancy**

---

**AN AMERICAN NATIONAL STANDARD**



**ASME PVHO-1-2019**  
(Revision of ASME PVHO-1-2016)

# **Safety Standard for Pressure Vessels for Human Occupancy**

---

**AN AMERICAN NATIONAL STANDARD**



**The American Society of  
Mechanical Engineers**

Two Park Avenue • New York, NY • 10016 USA

Date of Issuance: January 24, 2020

The next edition of this Standard is scheduled for publication in 2022.

ASME issues written replies to inquiries concerning interpretations of technical aspects of this Standard. Periodically certain actions of the ASME PVHO Committee may be published as Cases. Cases and interpretations are published on the ASME website under the Committee Pages at <http://cstools.asme.org/> as they are issued.

Errata to codes and standards may be posted on the ASME website under the Committee Pages to provide corrections to incorrectly published items, or to correct typographical or grammatical errors in codes and standards. Such errata shall be used on the date posted.

The Committee Pages can be found at <http://cstools.asme.org/>. There is an option available to automatically receive an e-mail notification when errata are posted to a particular code or standard. This option can be found on the appropriate Committee Page after selecting “Errata” in the “Publication Information” section.

ASME is the registered trademark of The American Society of Mechanical Engineers.

This code or standard was developed under procedures accredited as meeting the criteria for American National Standards. The Standards Committee that approved the code or standard was balanced to assure that individuals from competent and concerned interests have had an opportunity to participate. The proposed code or standard was made available for public review and comment that provides an opportunity for additional public input from industry, academia, regulatory agencies, and the public-at-large.

ASME does not “approve,” “rate,” or “endorse” any item, construction, proprietary device, or activity.

ASME does not take any position with respect to the validity of any patent rights asserted in connection with any items mentioned in this document, and does not undertake to insure anyone utilizing a standard against liability for infringement of any applicable letters patent, nor assume any such liability. Users of a code or standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, is entirely their own responsibility.

Participation by federal agency representative(s) or person(s) affiliated with industry is not to be interpreted as government or industry endorsement of this code or standard.

ASME accepts responsibility for only those interpretations of this document issued in accordance with the established ASME procedures and policies, which precludes the issuance of interpretations by individuals.

No part of this document may be reproduced in any form,  
in an electronic retrieval system or otherwise,  
without the prior written permission of the publisher.

The American Society of Mechanical Engineers  
Two Park Avenue, New York, NY 10016-5990

Copyright © 2020 by  
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS  
All rights reserved  
Printed in U.S.A.

# CONTENTS

Foreword .....	viii
Committee Roster .....	ix
Correspondence With the PVHO Committee .....	xii
Summary of Changes .....	xiv
<b>Section 1</b>	
General Requirements .....	1
1-1 Introduction .....	1
1-2 Scope .....	1
1-3 Exclusions .....	1
1-4 User Requirements .....	1
1-5 Manufacturer's Data Report .....	1
1-6 Materials .....	2
1-7 Design and Fabrication Requirements .....	2
1-8 Pressure Relief Devices .....	9
1-9 Marking .....	9
1-10 Nonmetallic Materials and Toxicity Off-Gas Testing .....	9
1-11 Risk Analysis .....	10
1-12 Lithium Batteries .....	10
1-13 Automatic Control and Software Safety .....	12
1-14 Operational Pressure Cycle .....	12
<b>Section 2</b>	
Viewports .....	19
2-1 General .....	19
2-2 Design .....	19
2-3 Material .....	30
2-4 Fabrication .....	33
2-5 Inspection .....	33
2-6 Marking .....	35
2-7 Pressure Testing .....	36
2-8 Installation of Windows in Chambers .....	36
2-9 Repair of Damaged Windows Prior to Being Placed in Service .....	37
2-10 Guidelines for Application of the Requirements of Section 2 .....	38
<b>Section 3</b>	
Quality Assurance for PVHO Manufacturers .....	88
3-1 General .....	88
3-2 Responsibilities .....	88
<b>Section 4</b>	
Piping Systems .....	89
4-1 General .....	89
4-2 Material Requirements .....	89
4-3 Design of Components .....	91
4-4 Selection and Limitations of Piping Components .....	92

4-5	Selection and Limitations of Piping Joints . . . . .	93
4-6	Supports . . . . .	94
4-7	Inspection . . . . .	94
4-8	Testing . . . . .	95
4-9	Systems . . . . .	95
<b>Section 5</b>	<b>Medical Hyperbaric Systems . . . . .</b>	<b>103</b>
5-1	General . . . . .	103
5-2	PVHO System Design . . . . .	104
5-3	Gas Systems . . . . .	104
5-4	Control Systems and Instrumentation . . . . .	104
5-5	Environmental Systems . . . . .	104
<b>Section 6</b>	<b>Diving Systems . . . . .</b>	<b>106</b>
6-1	General . . . . .	106
6-2	Design . . . . .	107
6-3	Pressure Boundary . . . . .	108
6-4	Systems . . . . .	110
6-5	Handling Systems . . . . .	114
6-6	Hyperbaric Evacuation Systems . . . . .	115
6-7	Testing and Trials . . . . .	117
<b>Section 7</b>	<b>Submersibles . . . . .</b>	<b>119</b>
7-1	General . . . . .	119
7-2	Pressure Boundary . . . . .	120
7-3	Piping . . . . .	121
7-4	Electrical Systems . . . . .	121
7-5	Life Support . . . . .	122
7-6	Fire Protection . . . . .	123
7-7	Navigation . . . . .	123
7-8	Communications . . . . .	124
7-9	Instrumentation . . . . .	124
7-10	Buoyancy, Stability, Emergency Ascent, and Entanglement . . . . .	124
7-11	Emergency Equipment . . . . .	125
 <b>Mandatory Appendices</b>		
I	Reference Codes, Standards, and Specifications . . . . .	126
II	Definitions . . . . .	128
 <b>Nonmandatory Appendices</b>		
A	Design of Supports and Lifting Attachments . . . . .	134
B	Recommendations for the Design of Through-Pressure Boundary Penetrations . . . . .	135
C	Recommended Practices for Color Coding and Labeling . . . . .	138
D	Guidelines for the Submission of a Case for the Use of Nonstandard Designs, Materials, and Construction for Non-Flexible PVHO Chamber Fabrication . . . . .	139
E	Guidelines for Preparing a Performance-Based Case for Flexible PVHO Chambers and Systems . . . . .	146
F	Useful References . . . . .	176

## Figures

1-7.13.1-1	Geometry of Cylinders . . . . .	15
1-7.13.1-2	Stiffener Geometry . . . . .	16
1-7.13.1-3	Sections Through Rings . . . . .	16
1-7.13.5-1	Values of $t/R_o$ and $L_c/R_o$ . . . . .	17
1-9-1	Form of Nameplate, U.S. Customary Units . . . . .	18
1-9-2	Form of Nameplate, SI Units . . . . .	18
2-2.2.1-1	Standard Window Geometries — Part 1 . . . . .	43
2-2.2.1-2	Standard Window Geometries — Part 2 . . . . .	44
2-2.2.1-3	Standard Window Geometries — Part 3 . . . . .	45
2-2.2.1-4	Standard Window Geometries — Part 4 . . . . .	46
2-2.5.1-1	Short-Term Critical Pressure of Flat Disk Acrylic Windows — Part 1 . . . . .	49
2-2.5.1-2	Short-Term Critical Pressure of Flat Disk Acrylic Windows — Part 2 . . . . .	50
2-2.5.1-3	Short-Term Critical Pressure of Flat Disk Acrylic Windows — Part 3 . . . . .	51
2-2.5.1-4	Short-Term Critical Pressure of Conical Frustum Acrylic Windows — Part 1 . . . . .	52
2-2.5.1-5	Short-Term Critical Pressure of Conical Frustum Acrylic Windows — Part 2 . . . . .	53
2-2.5.1-6	Short-Term Critical Pressure of Spherical Sector Acrylic Windows — Part 1 . . . . .	54
2-2.5.1-7	Short-Term Critical Pressure of Spherical Sector Acrylic Windows — Part 2 . . . . .	55
2-2.5.1-8	Short-Term Critical Pressure of Cylindrical Acrylic Windows Pressurized Internally — Part 1 . . . . .	56
2-2.5.1-9	Short-Term Critical Pressure of Cylindrical Acrylic Windows Pressurized Internally — Part 2 . . . . .	57
2-2.5.1-10	Short-Term Critical Pressure of Cylindrical Acrylic Windows Pressurized Externally . . . . .	58
2-2.5.1-11	Short-Term Elastic Buckling of Cylindrical Acrylic Windows Between Supports Under External Hydrostatic Pressure — Part 1 . . . . .	59
2-2.5.1-12	Short-Term Elastic Buckling of Cylindrical Acrylic Windows Between Supports Under External Hydrostatic Pressure — Part 2 . . . . .	60
2-2.5.1-13	Short-Term Elastic Buckling of Cylindrical Acrylic Windows Between Supports Under External Hydrostatic Pressure — Part 3 . . . . .	61
2-2.5.1-14	Short-Term Critical Pressure of Hyperhemispherical and NEMO-Type Acrylic Windows — Part 1 . . . . .	62
2-2.5.1-15	Short-Term Critical Pressure of Hyperhemispherical and NEMO-Type Acrylic Windows — Part 2 . . . . .	63
2-2.10.1-1	Seat Cavity Requirements — Conical Frustum Window, Spherical Sector Window With Conical Edge, and Flat Disk Window . . . . .	64
2-2.10.1-2	Seat Cavity Requirements — Double-Beveled Disk Window . . . . .	65
2-2.10.1-3	Seat Cavity Requirements — Spherical Sector Window With Square Edge . . . . .	66
2-2.10.1-4	Seat Cavity Requirements — Hemispherical Window With Equatorial Flange . . . . .	67
2-2.10.1-5	Seat Cavity Requirements — Cylindrical Window . . . . .	68
2-2.10.1-6	Seat Cavity Requirements — Hyperhemispherical Window . . . . .	69
2-2.10.1-7	Seat Cavity Requirements — NEMO Window (Standard Seat) . . . . .	70
2-2.10.1-8	Seat Cavity Requirements — NEMO Window (Seat With Extended Cyclic Fatigue Life) . . . . .	71
2-2.11.10-1	Bevels on Window Edges — Flat Disk Windows, Conical Frustum Windows, Spherical Sector Windows, Hyperhemispheres . . . . .	72
2-2.11.10-2	Bevels on Window Edges — Flanged Hemispherical Window, Spherical Sector Window With Square Edge, External Pressure and Internal Pressure of Cylindrical Windows . . . . .	73
2-2.11.11-1	Acceptable Configurations for Clear Viewport Retaining Covers . . . . .	74
2-2.14.11-1	Dimensional Tolerances for Penetrations in Acrylic Windows . . . . .	75
2-2.14.15-1	Dimensional Tolerances for Inserts in Acrylic Windows . . . . .	77

2-2.14.16-1	Typical Shapes of Inserts . . . . .	78
2-2.14.22-1	Seal Configurations for Inserts in Acrylic Windows . . . . .	79
2-2.14.24-1	Restraints for Inserts in Acrylic Windows . . . . .	80
4-9.14.2-1	Flow Diagram of Apparatus for Measuring the Concentration of Hydrocarbons in a Stream of Air or Other Gas After It Has Passed Through a Test Hose . . . . .	102
6-6.2.2-1	Placement and Design of Markings for Hyperbaric Evacuation Units Designed to Float in Water	118
6-6.2.2-2	Markings for Hyperbaric Evacuation Units Designed to Float in Water . . . . .	118
B-2-1	Acceptable Weld Nozzle Penetrators . . . . .	136
B-3-1	Acceptable Threads and Inserts . . . . .	137
E-3.3.1-1	Cook's Diagram: Atmosphere of Increased Burning Rate . . . . .	173
E-5.2.2.1-1	Number of Test Samples Required for Alternate Creep Test Procedure . . . . .	174
E-5.2.5.1-1	Time Versus Test Temperature for Accelerated Aging Test . . . . .	175

**Tables**

1-10-1	Conversion Factor, $F_p$ (for PVHO Occupation Exceeding 8 hr) . . . . .	18
2-2.3.1-1	Conversion Factors for Acrylic Flat Disk Windows . . . . .	46
2-2.3.1-2	Conversion Factors for Acrylic Conical Frustum Windows and Double-Beveled Disk Windows	47
2-2.3.1-3	Conversion Factors for Acrylic Spherical Sector Windows With Conical Edge, Hyperhemispherical Windows With Conical Edge, and NEMO-Type Windows With Conical Edge . . . . .	47
2-2.3.1-4	Conversion Factors for Acrylic Spherical Sector Windows With Square Edge and Hemispherical Windows With Equatorial Flange . . . . .	48
2-2.3.1-5	Conversion Factors for Acrylic Cylindrical Windows . . . . .	48
2-2.3.2-1	Conical Frustum Windows for Design Pressures in Excess of 10,000 psi (69 MPa) . . . . .	49
2-2.14.13-1	Specified Values of Physical Properties for Polycarbonate Plastic . . . . .	76
2-2.14.13-2	Specified Values of Physical Properties for Cast Nylon Plastic . . . . .	76
2-3.4-1	Specified Values of Physical Properties for Each Lot . . . . .	81
2-3.4-2	Specified Values of Physical Properties for Each Casting . . . . .	83
2-4.5-1	Annealing Schedule for Acrylic Windows . . . . .	85
4-2.1.1-1	Maximum Allowable Stress Values for Seamless Pipe and Tube Materials Not Listed in Nonmandatory Appendix A of ASME B31.1 . . . . .	101
4-7.1-1	Mandatory Minimum Nondestructive Examinations for Pressure Welds in Piping Systems for Pressure Vessels for Human Occupancy . . . . .	101
4-9.14.2-1	Maximum Allowable Concentration of Hydrocarbons in Air Passing Through Hose . . . . .	102
C-1	U.S. Navy Color Codes . . . . .	138
C-2	IMO Color Codes . . . . .	138
D-7.1-1	Tabulated Data for Performance of "W-Test" for Normality of Data Set . . . . .	145
E-1.1-1	Compliance Matrix for ASME PVHO-1 Cases . . . . .	159

**Forms**

PVHO-1 GR-1	Manufacturer's Data Report for Pressure Vessels for Human Occupancy . . . . .	13
PVHO-1 GR-1S	Manufacturer's Data Report Supplementary Sheet . . . . .	14
PVHO-1 VP-1	Fabrication Certification for Acrylic Windows . . . . .	41
PVHO-1 VP-2	Acrylic Window Design Certification . . . . .	42
PVHO-1 VP-3	Material Manufacturer's Certification for Acrylic . . . . .	82
PVHO-1 VP-4	Material Testing Certification for Acrylic . . . . .	84

PVHO-1 VP-5	Pressure Testing Certification . . . . .	86
PVHO-1 VP-6	Acrylic Window Repair Certification . . . . .	87



# FOREWORD

Early in 1971, an ad hoc committee was formed by action of the ASME Codes and Standards Policy Board to develop design rules for pressure vessels for human occupancy. The importance of this task was soon recognized, and the ASME Safety Code Committee on Pressure Vessels for Human Occupancy (PVHO) was established in 1974 to continue the work of the ad hoc committee. Initially, this committee was to confine its activity to the pressure boundary of such systems. It was to reference existing ASME Boiler and Pressure Vessel Code (BPVC) Sections, insofar as practicable, adapting them for application to pressure vessels for human occupancy. The common practice hitherto had been to design such chambers in accordance with Section VIII, Division 1 of ASME BPVC; however, a number of important considerations were not covered in those rules. Among these were requirements for viewports and the in-service use of pressure relief valves, and special material toughness requirements. This Standard provides the necessary rules to supplement that Section, and also Section VIII, Division 2 of ASME BPVC. The user is expected to be familiar with the principles and application of the Code Sections.

ASME BPVC criteria furnish the baseline for design. In ASME PVHO-1, design temperature is limited to 0°F to 150°F (–18°C to 66°C). Supporting structure and lifting loads are given special attention. Certain design details permitted by Section VIII are excluded. A major addition is the inclusion of design rules for acrylic viewports ([Section 2](#)). The formulation of rules for these vital and critical appurtenances was one of the reasons for establishing the PVHO Committee. Finally, all chambers designed for external pressure are required to be subjected to an external pressure hydrostatic test or pneumatic test.

The 2007 edition was completely rewritten and reformatted from the 2002 edition. [Section 1](#), General Requirements, is intended to be used for all PVHOs, regardless of use. The rules for external pressure design were expanded to include unstiffened and ring-stiffened cylinders, in addition to spheres. Other additions included Sections pertaining to application-specific PVHOs. Sections were included for medical hyperbaric systems, diving systems, submersibles, and quality assurance. The Piping Systems Section was expanded. Where possible, Mandatory Appendices were incorporated into the body of the Standard. All forms were revised to reflect the document (PVHO-1), an abbreviation denoting the corresponding section (e.g., General Requirements is GR), and the form number within that Section. An example is [PVHO-1 Form GR-1](#).

The 2012 edition included expansions made to the General Requirements, Viewports, and Diving Systems Sections.

The 2016 edition included additional expansions made to the General Requirements, Viewports, Medical Hyperbaric Systems, and Diving Systems Sections. It included a new Nonmandatory Appendix for preparing PVHO performance-based Cases for flexible chambers. There is continuing work being accomplished by the Subcommittees in the areas of PVHOs using nonstandard materials, including nonmetallic PVHOs. A companion document (ASME PVHO-2) that covers in-service guidelines for PVHOs has been published.

The 2019 edition of PVHO-1 continues the work to address complete PVHO systems and PVHOs made from nonstandard materials. In support of this work, definitions in [Mandatory Appendix II](#) and various forms were added or updated to reflect the differences in approach to documenting the entire PVHO system as a whole rather than as single or multiple pressure vessels/chambers. Additionally, changes were made to this edition in efforts to clarify several design standards and requirements for easier understanding and implementation by all users of this Standard.

Interpretations, Code Cases, and errata to ASME PVHO-1 are published on the following ASME web page: <https://cstools.asme.org/csconnect/CommitteePages.cfm?Committee=N10050000>.

The 2019 edition of ASME PVHO-1 was approved and adopted by the American National Standards Institute as meeting the criteria as an American National Standard on December 4, 2019. Previous editions were published in 1977, 1981, 1984, 1987, 1993, 1997, 2002, 2007, 2012, and 2016.

# ASME PRESSURE VESSELS FOR HUMAN OCCUPANCY COMMITTEE

(The following is the roster of the Committee as of February 19, 2019.)

## STANDARDS COMMITTEE OFFICERS

**G. Wolfe**, *Chair*  
**J. Witney**, *Vice Chair*  
**E. Lawson**, *Secretary*

## STANDARDS COMMITTEE PERSONNEL

<b>J. E. Crouch</b> , Southwest Research Institute	<b>J. Witney</b> , Atlantis Submarines International
<b>B. Faircloth</b> , FMS Engineering, LLC	<b>G. Wolfe</b> , Southwest Research Institute
<b>M. A. Frey</b> , Naval Sea Systems Command	<b>E. G. Fink</b> , <i>Delegate</i> , Fink Engineering Pty., Ltd.
<b>T. R. Galloway</b> , Naval Sea Systems Command	<b>H. Pauli</b> , <i>Delegate</i> , Germanischer Lloyd AG
<b>B. Kemper</b> , Kemper Engineering Services, LLC	<b>J. S. Selby</b> , <i>Delegate</i> , SOS Group Global, Ltd.
<b>W. Kohnen</b> , Hydrospace Group, Inc.	<b>L. Cross</b> , <i>Alternate</i> , Kemper Engineering Services, LLC
<b>D. Lawrence</b> , U.S. Coast Guard	<b>J. P. Hierholzer</b> , <i>Alternate</i> , DNV GL
<b>E. Lawson</b> , The American Society of Mechanical Engineers	<b>J. K. Martin</b> , <i>Alternate</i> , Perry Technologies
<b>S. Reimers</b> , Reimers Systems, Inc.	<b>P. Selby</b> , <i>Alternate</i> , SOS Group Global, Ltd.
<b>G. Richards</b> , Blanson, Ltd.	<b>M. W. Allen</b> , <i>Contributing Member</i> , Microbaric Oxygen Systems, LLC
<b>T. C. Schmidt</b> , Lockheed Martin	<b>W. F. Crowley, Jr.</b> , <i>Contributing Member</i> , Aerospace & Undersea Support Services, LLC
<b>K. A. Smith</b> , U.S. Coast Guard	<b>W. Davison</b> , <i>Contributing Member</i>
<b>R. C. Smith</b> , Naval Facilities Engineering Command, Ocean Facilities Program	<b>G. J. Jacob</b> , <i>Contributing Member</i> , Navy Experimental Diving Unit
<b>J. Stromer</b> , Triton Submarines	<b>J. Maison</b> , <i>Contributing Member</i> , Adaptive Computer Technology, Inc.
<b>D. Talati</b> , Sechrist Industries, Inc.	<b>T. Marohl</b> , <i>Contributing Member</i>
<b>R. Thomas</b> , American Bureau of Shipping	<b>J. C. Sheffield</b> , <i>Contributing Member</i> , International ATMO, Inc.
<b>M. R. Walters</b> , Oceaneering International, Inc.	

## HONORARY MEMBERS

<b>R. J. Dzikowski</b>	<b>L. G. Malone</b> , Plastic Supply & Fabric, Inc.
<b>F. T. Gorman</b>	<b>R. P. Swanson</b>

## SPECIAL PROJECTS TASK GROUP

<b>J. Witney</b> , <i>Chair</i> , Atlantis Submarines International	<b>G. Richards</b> , Blanson, Ltd.
<b>J. E. Crouch</b> , Southwest Research Institute	<b>R. C. Smith</b> , Naval Facilities Engineering Command, Ocean Facilities Program
<b>E. G. Fink</b> , Fink Engineering Pty., Ltd.	<b>G. Wolfe</b> , Southwest Research Institute
<b>M. A. Frey</b> , Naval Sea Systems Command	<b>L. Cross</b> , <i>Alternate</i> , Kemper Engineering Services, LLC
<b>T. R. Galloway</b> , Naval Sea Systems Command	<b>M. W. Allen</b> , <i>Contributing Member</i> , Microbaric Oxygen Systems, LLC
<b>B. Kemper</b> , Kemper Engineering Services, LLC	<b>K. K. Kemper</b> , <i>Contributing Member</i> , Kemper Engineering Services, LLC
<b>W. Kohnen</b> , Hydrospace Group, Inc.	
<b>S. Reimers</b> , Reimers Systems, Inc.	

## TASK GROUP ON TUNNELING

<b>L. Cross</b> , Kemper Engineering Services, LLC	<b>B. Kemper</b> , Kemper Engineering Services, LLC
<b>G. L. East</b> , ASI Marine	<b>W. Kohnen</b> , Hydrospace Group, Inc.
<b>E. G. Fink</b> , Fink Engineering Pty., Ltd.	<b>S. Reimers</b> , Reimers Systems, Inc.
<b>J. P. Hierholzer</b> , DNV GL	<b>M. W. Allen</b> , <i>Contributing Member</i> , Microbaric Oxygen Systems, LLC

## SUBCOMMITTEE ON DESIGN AND PIPING SYSTEMS

**T. C. Schmidt**, *Chair*, Lockheed Martin  
**B. Faircloth**, *Vice Chair*, FMS Engineering, LLC  
**E. Lawson**, *Secretary*, The American Society of Mechanical Engineers  
**G. Bryant**, Consultant  
**W. Davison**  
**R. K. Dixit**, Reimers Systems, Inc.  
**P. Forte**, Woods Hole Oceanographic Institution  
**M. A. Frey**, Naval Sea Systems Command  
**T. R. Galloway**, Naval Sea Systems Command  
**C. Gaumont**, Groupe Medical Gaumont  
**B. Humberstone**, Diving Technical Advisor  
**G. J. Jacob**, Navy Experimental Diving Unit  
**B. Kemper**, Kemper Engineering Services, LLC  
**S. Reimers**, Reimers Systems, Inc.  
**D. A. Renear**, Aqua-Air Industries, Inc.

**G. Richards**, Blanson, Ltd.  
**R. Thomas**, American Bureau of Shipping  
**M. R. Walters**, Oceaneering International, Inc.  
**J. S. Selby**, *Delegate*, SOS Group Global, Ltd.  
**L. Cross**, *Alternate*, Kemper Engineering Services, LLC  
**J. K. Martin**, *Alternate*, Perry Technologies  
**J. N. Pollack**, *Alternate*, U.S. Navy  
**P. Selby**, *Alternate*, SOS Group Global, Ltd.  
**R. M. Webb**, *Alternate*, Naval Sea Systems Command  
**M. W. Allen**, *Contributing Member*, Microbaric Oxygen Systems, LLC  
**F. Burman**, *Contributing Member*, Divers Alert Network  
**W. F. Crowley, Jr.**, *Contributing Member*, Aerospace & Undersea Support Services, LLC  
**K. K. Kemper**, *Contributing Member*, Kemper Engineering Services, LLC

## SUBCOMMITTEE ON DIVING SYSTEMS

**R. Thomas**, *Chair*, American Bureau of Shipping  
**T. R. Galloway**, *Vice Chair*, Naval Sea Systems Command  
**E. Lawson**, *Secretary*, The American Society of Mechanical Engineers  
**G. Bryant**, Consultant  
**W. F. Crowley, Jr.**, Aerospace & Undersea Support Services, LLC  
**G. L. East**, ASI Marine  
**B. Faircloth**, FMS Engineering, LLC  
**B. Humberstone**, Diving Technical Advisor  
**B. Kemper**, Kemper Engineering Services, LLC  
**D. Lawrence**, U.S. Coast Guard  
**J. K. Martin**, Perry Technologies  
**D. A. Renear**, Aqua-Air Industries, Inc.

**J. S. Selby**, SOS Group Global, Ltd.  
**K. A. Smith**, U.S. Coast Guard  
**M. R. Walters**, Oceaneering International, Inc.  
**E. G. Fink**, *Delegate*, Fink Engineering Pty., Ltd.  
**H. Pauli**, *Delegate*, Germanischer Lloyd AG  
**L. Cross**, *Alternate*, Kemper Engineering Services, LLC  
**T. Gilman**, *Alternate*, U.S. Coast Guard  
**P. Selby**, *Alternate*, SOS Group Global, Ltd.  
**M. W. Allen**, *Contributing Member*, Microbaric Oxygen Systems, LLC  
**K. K. Kemper**, *Contributing Member*, Kemper Engineering Services, LLC  
**T. Marohl**, *Contributing Member*

## SUBCOMMITTEE ON GENERAL REQUIREMENTS

**M. A. Frey**, *Chair*, Naval Sea Systems Command  
**B. Kemper**, *Vice Chair*, Kemper Engineering Services, LLC  
**E. Lawson**, *Secretary*, The American Society of Mechanical Engineers  
**J. E. Crouch**, Southwest Research Institute  
**T. R. Galloway**, Naval Sea Systems Command  
**S. Reimers**, Reimers Systems, Inc.  
**J. Witney**, Atlantis Submarines International

**L. Cross**, *Alternate*, Kemper Engineering Services, LLC  
**J. N. Pollack**, *Alternate*, U.S. Navy  
**R. M. Webb**, *Alternate*, Naval Sea Systems Command  
**M. W. Allen**, *Contributing Member*, Microbaric Oxygen Systems, LLC  
**G. J. Jacob**, *Contributing Member*, Navy Experimental Diving Unit  
**K. K. Kemper**, *Contributing Member*, Kemper Engineering Services, LLC

## SUBCOMMITTEE ON MEDICAL HYPERBARIC SYSTEMS

**G. Richards**, *Chair*, Blanson, Ltd.  
**T. Dingman**, *Vice Chair*, Healogics  
**E. Lawson**, *Secretary*, The American Society of Mechanical Engineers  
**F. Burman**, Divers Alert Network  
**L. Cross**, Kemper Engineering Services, LLC  
**W. T. Gurnee**, Oxyheal Health Group  
**S. Reimers**, Reimers Systems, Inc.  
**R. C. Smith**, Naval Facilities Engineering Command, Ocean Facilities Program  
**D. Talati**, Sechrist Industries, Inc.

**E. G. Fink**, *Delegate*, Fink Engineering Pty., Ltd.  
**H. Pauli**, *Delegate*, Germanischer Lloyd AG  
**B. Kemper**, *Alternate*, Kemper Engineering Services, LLC  
**M. W. Allen**, *Contributing Member*, Microbaric Oxygen Systems, LLC  
**W. Davison**, *Contributing Member*  
**K. W. Evans**, *Contributing Member*, Perry Baromedical  
**K. K. Kemper**, *Contributing Member*, Kemper Engineering Services, LLC  
**J. C. Sheffield**, *Contributing Member*, International ATMO, Inc.  
**N. To**, *Contributing Member*, U.S. Food and Drug Administration

## SUBCOMMITTEE ON POST CONSTRUCTION

**J. E. Crouch**, *Chair*, Southwest Research Institute  
**R. C. Smith**, *Vice Chair*, Naval Facilities Engineering Command, Ocean Facilities Program  
**E. Lawson**, *Secretary*, The American Society of Mechanical Engineers  
**G. Bryant**, Consultant  
**T. Dingman**, Healogics  
**M. A. Frey**, Naval Sea Systems Command  
**T. R. Galloway**, Naval Sea Systems Command  
**D. R. Hurd**, Atlantis Submarines International  
**B. Kemper**, Kemper Engineering Services, LLC  
**W. Kohnen**, Hydrospace Group, Inc.  
**D. Lawrence**, U.S. Coast Guard  
**J. K. Martin**, Perry Technologies  
**G. Richards**, Blanson, Ltd.  
**D. Talati**, Sechrist Industries, Inc.  
**J. Witney**, Atlantis Submarines International

**L. Cross**, *Alternate*, Kemper Engineering Services, LLC  
**T. Gilman**, *Alternate*, U.S. Coast Guard  
**J. N. Pollack**, *Alternate*, U.S. Navy  
**R. M. Webb**, *Alternate*, Naval Sea Systems Command  
**M. W. Allen**, *Contributing Member*, Microbaric Oxygen Systems, LLC  
**J. Bell**, *Contributing Member*, Fink Engineering Pty., Ltd.  
**W. F. Crowley, Jr.**, *Contributing Member*, Aerospace & Undersea Support Services, LLC  
**W. Davison**, *Contributing Member*  
**P. Forte**, *Contributing Member*, Woods Hole Oceanographic Institution  
**B. Humberstone**, *Contributing Member*, Diving Technical Advisor  
**G. J. Jacob**, *Contributing Member*, Navy Experimental Diving Unit  
**K. K. Kemper**, *Contributing Member*, Kemper Engineering Services, LLC  
**J. C. Sheffield**, *Contributing Member*, International ATMO, Inc.

## SUBCOMMITTEE ON SUBMERSIBLES

**R. Thomas**, *Chair*, American Bureau of Shipping  
**E. Lawson**, *Secretary*, The American Society of Mechanical Engineers  
**G. Bryant**, Consultant  
**J. P. Hierholzer**, DNV GL  
**D. R. Hurd**, Atlantis Submarines International  
**B. Kemper**, Kemper Engineering Services, LLC  
**W. Kohnen**, Hydrospace Group, Inc.  
**J. K. Martin**, Perry Technologies  
**K. A. Smith**, U.S. Coast Guard  
**J. Stromer**, Triton Submarines  
**M. R. Walters**, Oceaneering International, Inc.

**J. Witney**, Atlantis Submarines International  
**H. Pauli**, *Delegate*, Germanischer Lloyd AG  
**L. Cross**, *Alternate*, Kemper Engineering Services, LLC  
**D. Lawrence**, *Alternate*, U.S. Coast Guard  
**W. F. Crowley, Jr.**, *Contributing Member*, Aerospace & Undersea Support Services, LLC  
**T. R. Galloway**, *Contributing Member*, Naval Sea Systems Command  
**K. K. Kemper**, *Contributing Member*, Kemper Engineering Services, LLC  
**R. M. Webb**, *Contributing Member*, Naval Sea Systems Command

## SUBCOMMITTEE ON VIEWPORTS

**B. Kemper**, *Chair*, Kemper Engineering Services, LLC  
**J. Witney**, *Vice Chair*, Atlantis Submarines International  
**E. Lawson**, *Secretary*, The American Society of Mechanical Engineers  
**G. Bryant**, Consultant  
**B. Faircloth**, FMS Engineering, LLC  
**D. R. Hurd**, Atlantis Submarines International  
**W. Kohnen**, Hydrospace Group, Inc.  
**D. Lawrence**, U.S. Coast Guard  
**D. A. Renear**, Aqua-Air Industries, Inc.  
**G. Richards**, Blanson, Ltd.

**R. C. Smith**, Naval Facilities Engineering Command, Ocean Facilities Program  
**J. Stromer**, Triton Submarines  
**D. Talati**, Sechrist Industries, Inc.  
**R. Thomas**, American Bureau of Shipping  
**L. Cross**, *Alternate*, Kemper Engineering Services, LLC  
**J. K. Martin**, *Alternate*, Perry Technologies  
**M. W. Allen**, *Contributing Member*, Microbaric Oxygen Systems, LLC  
**K. K. Kemper**, *Contributing Member*, Kemper Engineering Services, LLC

# CORRESPONDENCE WITH THE PVHO COMMITTEE

**General.** ASME Standards are developed and maintained with the intent to represent the consensus of concerned interests. As such, users of this Standard may interact with the Committee by requesting interpretations, proposing revisions or a case, and attending Committee meetings. Correspondence should be addressed to:

Secretary, PVHO Standards Committee  
The American Society of Mechanical Engineers  
Two Park Avenue  
New York, NY 10016-5990  
<http://go.asme.org/Inquiry>

**Proposing Revisions.** Revisions are made periodically to the Standard to incorporate changes that appear necessary or desirable, as demonstrated by the experience gained from the application of the Standard. Approved revisions will be published periodically.

The Committee welcomes proposals for revisions to this Standard. Such proposals should be as specific as possible, citing the paragraph number(s), the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent documentation.

**Proposing a Case.** Cases may be issued to provide alternative rules when justified, to permit early implementation of an approved revision when the need is urgent, or to provide rules not covered by existing provisions. Cases are effective immediately upon ASME approval and shall be posted on the ASME Committee web page.

Requests for Cases shall provide a Statement of Need and Background Information. The request should identify the Standard and the paragraph, figure, or table number(s), and be written as a Question and Reply in the same format as existing Cases. Requests for Cases should also indicate the applicable edition(s) of the Standard to which the proposed Case applies.

**Interpretations.** Upon request, the PVHO Standards Committee will render an interpretation of any requirement of the Standard. Interpretations can only be rendered in response to a written request sent to the Secretary of the PVHO Standards Committee.

Requests for interpretation should preferably be submitted through the online Interpretation Submittal Form. The form is accessible at <http://go.asme.org/InterpretationRequest>. Upon submittal of the form, the Inquirer will receive an automatic e-mail confirming receipt.

If the Inquirer is unable to use the online form, he/she may mail the request to the Secretary of the PVHO Standards Committee at the above address. The request for an interpretation should be clear and unambiguous. It is further recommended that the Inquirer submit his/her request in the following format:

- |                         |   |
|-------------------------|---|
| Subject:                | Cite the applicable paragraph number(s) and the topic of the inquiry in one or two words.   |
| Edition:                | Cite the applicable edition of the Standard for which the interpretation is being requested.  |
| Question:               | Phrase the question as a request for an interpretation of a specific requirement suitable for general understanding and use, not as a request for an approval of a proprietary design or situation. Please provide a condensed and precise question, composed in such a way that a "yes" or "no" reply is acceptable. |
| Proposed Reply(ies):    | Provide a proposed reply(ies) in the form of "Yes" or "No," with explanation as needed. If entering replies to more than one question, please number the questions and replies.   |
| Background Information: | Provide the Committee with any background information that will assist the Committee in understanding the inquiry. The Inquirer may also include any plans or drawings that are necessary to explain the question; however, they should not contain proprietary names or information.                                 |

Requests that are not in the format described above may be rewritten in the appropriate format by the Committee prior to being answered, which may inadvertently change the intent of the original request.

Moreover, ASME does not act as a consultant for specific engineering problems or for the general application or understanding of the Standard requirements. If, based on the inquiry information submitted, it is the opinion of the Committee that the Inquirer should seek assistance, the inquiry will be returned with the recommendation that such assistance be obtained.

ASME procedures provide for reconsideration of any interpretation when or if additional information that might affect an interpretation is available. Further, persons aggrieved by an interpretation may appeal to the cognizant ASME Committee or Subcommittee. ASME does not “approve,” “certify,” “rate,” or “endorse” any item, construction, proprietary device, or activity.

**Attending Committee Meetings.** The PVHO Standards Committee regularly holds meetings and/or telephone conferences that are open to the public. Persons wishing to attend any meeting and/or telephone conference should contact the Secretary of the PVHO Standards Committee.

# ASME PVHO-1-2019

## SUMMARY OF CHANGES

Following approval by the ASME PVHO-1 Committee and ASME, and after public review, ASME PVHO-1-2019 was approved by the American National Standards Institute on December 4, 2019.

ASME PVHO-1-2019 includes the following changes identified by a margin note, **(19)**.

<i>Page</i>	<i>Location</i>	<i>Change</i>
2	1-7.1	Subparagraphs (c)(1) through (c)(3) revised
3	1-7.8	Subparagraph (c) added
4	1-7.9	Subparagraph (k) revised
8	1-7.14	Subparagraph (f) added
10	1-12	Added
12	1-13	Added
12	1-14	Added
19	2-2.1	Revised
24	2-2.8.3	Title revised
32	2-3.8	(1) First paragraph and subpara. (a) revised (2) In subpara. (b), second sentence corrected by errata to read “acrylic plastic weighing about”
32	2-3.11	Added
34	2-5.4.1	Added
35	2-6.1	Revised
36	2-7.3	Revised
42	PVHO-1 Form VP-2	Revised
89	4-1.2	(1) Former para. 4-1.2.3 redesignated as subpara. 4-1.2.2(c) (2) Paragraph 4-1.2.4 redesignated as para. 4-1.2.3 (3) Paragraph 4-1.2.5 deleted
101	Table 4-7.1-1	General Note (b) corrected by errata to read MT
103	5-1.4	Revised in its entirety
104	5-1.9	Added
104	5-2	Revised
104	5-3.2	First paragraph revised
106	Section 6	Revised in its entirety
128	Mandatory Appendix II	(1) Definitions of <i>air-ventilated PVHO</i> , <i>fabricator</i> , <i>manufacturer</i> , <i>material manufacturer</i> , <i>Professional Engineer</i> , and <i>systems integrator</i> added (2) Definitions of <i>fabricator of windows</i> , <i>manufacturer (component)</i> , <i>manufacturer of plastic (window)</i> , and <i>manufacturer (PVHO)</i> deleted (3) Definition of <i>risk</i> corrected by errata to read occurrence
139	Nonmandatory Appendix D	Title revised
139	D-2	Revised

<i>Page</i>	<i>Location</i>	<i>Change</i>
146	Nonmandatory Appendix E	Title revised
146	E-1.1	Revised
147	E-2.2	Fourth paragraph revised
149	E-2.8	Third paragraph revised
149	E-3	(1) Paragraph E-3.1 revised (2) Paragraph E-3.4 deleted
152	E-4.12	Subparagraph (f) revised
172	Table E-1.1-1	Added
176	Nonmandatory Appendix F	(1) Title for MIL-H-2815 added (2) Addresses updated (3) Publications from Naval Ordnance Safety and Security Activity and U.S. Department of Health and Human Services added



# Section 1

## General Requirements

### 1-1 INTRODUCTION

This Standard defines the requirements that are applicable to all Pressure Vessels for Human Occupancy (PVHOs) fabricated to this Standard (Sections 1 through 4) and shall be used in conjunction with specific requirements in other Sections (Sections 5 through 7, as applicable) and Mandatory Appendices of this Standard. In the event of conflict between Sections 1 through 4 and other Sections (5 through 7), the application-specific requirements from Sections 5 through 7 shall govern.

PVHOs shall be designed, fabricated, inspected, tested, marked, and stamped in accordance with the requirements of this Standard and of the ASME Boiler and Pressure Vessel Code (ASME BPVC), Section VIII, Division 1 or Division 2, unless otherwise permitted within this Standard.

In-service requirements for PVHOs are found in ASME PVHO-2.

### 1-2 SCOPE

#### 1-2.1 Application

This Standard applies to all pressure vessels that enclose a human within their pressure boundary while under internal or external pressure exceeding a differential pressure of 2 psi (15 kPa). PVHOs include, but are not limited to, submersibles, diving bells, and personnel transfer capsules, as well as decompression, recompression, hypobaric, and hyperbaric PVHOs.

#### 1-2.2 Geometry

The scope of this Standard in relation to the geometry is the pressure boundary as defined in the User's Design Specification and shall include, but not be limited to, the following:

- (a) shells of revolution
- (b) openings and their reinforcements
- (c) nozzles and other connections
- (d) flat heads
- (e) quick-actuating closures
- (f) vessel penetrations
- (g) attachments and supports
- (h) access openings
- (i) viewports
- (j) pressure relief devices

- (k) pressure-retaining covers for vessel openings

### 1-2.3 Limitations

The pressure boundary of the PVHO shall be as follows:

- (a) welding end connection for the first circumferential joint for welded connections
- (b) the first threaded joint for screwed connections
- (c) the face of the first flange for bolted, flanged connections
- (d) the first sealing surface for proprietary connections or fittings

### 1-3 EXCLUSIONS

The following types of vessels are excluded from this Standard:

- (a) nuclear reactor containments
- (b) pressurized airplane cabins
- (c) aerospace vehicle cabins
- (d) caissons

### 1-4 USER REQUIREMENTS

It is the responsibility of the user, or an agent acting for the user who intends that a PVHO be designed, fabricated, inspected, tested, marked, stamped, and certified to be in compliance with this Standard, to provide or cause to be provided for such PVHO, a User's Design Specification. The User's Design Specification shall set forth the intended operating conditions of the PVHO to provide the basis for design. It shall identify the external environment to which the PVHO will be exposed, the intended function of the PVHO, mechanical loads imposed on the PVHO, specific installation requirements, and applicable codes and standards.

### 1-5 MANUFACTURER'S DATA REPORT

The manufacturer or a designated agent shall make design calculations and prepare a Manufacturer's Data Report stating that the design, as shown on the design drawings, complies with this Standard and the User's Design Specification.

A registered Professional Engineer, or the equivalent in other countries, shall certify that the Manufacturer's Data Report is in compliance with this Standard and the User's Design Specification.