

**ANSI/AIAA S-080A-2018**  
**(Revision of AIAA S-080-1998)**

# Standard

## **Space Systems – Metallic Pressure Vessels, Pressurized Structures, and Pressure Components**

AIAA standards are copyrighted by the American Institute of Aeronautics and Astronautics (AIAA), 12700 Sunrise Valley Drive, Reston, VA 20191-5807 USA. All rights reserved.

AIAA grants you a license as follows: The right to download an electronic file of this AIAA standard for temporary storage on one computer for purposes of viewing, and/or printing one copy of the AIAA standard for individual use. Neither the electronic file nor the hard copy print may be reproduced in any way. In addition, the electronic file may not be distributed elsewhere over computer networks or otherwise. The hard copy print may only be distributed to other employees for their internal use within your organization.

**ANSI/AIAA S-080A-2018**  
**(Revision of AIAA S-080-1998)**

# **American National Standard**

## **Space Systems—Metallic Pressure Vessels, Pressurized Structures, and Pressure Components**

**Sponsored by**

American Institute of Aeronautics and Astronautics

**Approved 12 March 2018**

American National Standards Institute

**Approved 20 March 2018**

**Abstract**

This standard establishes baseline requirements for the design, analysis, fabrication, test, operation, and maintenance of metallic pressure vessels, pressurized structures, batteries, heat pipes, and cryostats, dewars, sealed containers, accumulators, and pressure components such as lines, fittings, hoses, and bellows made of metals. These components are used for pressurized, hazardous, or nonhazardous liquid or gas storage in space systems including spacecraft and launch vehicles.

Approval of an American National Standard requires verification by ANSI that the requirements for due process, consensus, and other criteria have been met by the standards developer.

Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that a concerted effort be made toward their resolution.

The use of American National Standards is completely voluntary; their existence does not in any respect preclude anyone, whether he has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

The American National Standards Institute does not develop standards and will in no circumstances give an interpretation of any American National Standard. Moreover, no person shall have the right or authority to issue an interpretation of an American National Standard in the name of the American National Standards Institute. Requests for interpretations should be addressed to the secretariat or sponsor whose name appears on the title page of this standard.

**CAUTION NOTICE:** This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken to affirm, revise, or withdraw this standard no later than five years from the date of approval. Purchasers of American National Standards may receive current information on all standards by calling or writing the American National Standards Institute.

Published by  
**American Institute of Aeronautics and Astronautics**  
**12700 Sunrise Valley Drive, Suite 200, Reston, VA 20191**

Copyright © 2018 American Institute of Aeronautics and  
Astronautics  
All rights reserved

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

Printed in the United States of America

ISBN 978-1-62410-541-8

## Contents

<b>1</b>	<b>Scope</b> .....	<b>1</b>
<b>1.1</b>	<b>Purpose</b> .....	<b>1</b>
<b>1.2</b>	<b>Applicability</b> .....	<b>1</b>
<b>1.3</b>	<b>Designation of Responsibilities</b> .....	<b>1</b>
1.3.1	Owner.....	1
1.3.2	Procuring Authority.....	2
1.3.3	Manufacturer.....	2
<b>2</b>	<b>Tailoring</b> .....	<b>2</b>
<b>3</b>	<b>Applicable Documents</b> .....	<b>2</b>
<b>4</b>	<b>Vocabulary</b> .....	<b>3</b>
<b>4.1</b>	<b>Acronyms and Abbreviated Terms</b> .....	<b>3</b>
<b>4.2</b>	<b>Terms and Definitions</b> .....	<b>5</b>
<b>5</b>	<b>General Design</b> .....	<b>10</b>
<b>5.1</b>	<b>System Analysis</b> .....	<b>10</b>
5.1.1	Service Classification.....	11
5.1.2	Service Category.....	11
5.1.3	Maximum Expected Operating Pressure.....	11
5.1.4	Maximum External Pressure Differential.....	11
5.1.5	Load, Acoustic, Shock, and Vibration Environment.....	11
5.1.6	Service Life.....	12
5.1.7	Volume Capacity.....	12
5.1.8	Pressurized Hardware Assessment.....	12
5.1.9	Physical Envelope.....	12
5.1.10	Acceptable Leak Rate.....	13
5.1.11	Mass.....	13
5.1.12	Cleanliness Level.....	13
5.1.13	Fluids.....	13
5.1.14	Shipping Environment.....	13
5.1.15	Reserved.....	13
5.1.16	Thermal Environment.....	13
5.1.17	Unique Operating Environments.....	13
5.1.18	Reliability.....	13
<b>5.2</b>	<b>Pressurized Hardware Design Parameters</b> .....	<b>13</b>
5.2.1	Burst Factor.....	14
5.2.2	Design Burst Pressure.....	15
5.2.3	Proof Pressure.....	16
5.2.4	Design Safety Factor.....	16
5.2.5	Margin of Safety.....	16
5.2.6	Negative Pressure Differential Design.....	17
5.2.7	Volume Capacity Design.....	17
5.2.8	Physical Envelope Design.....	17
5.2.9	Mass Design.....	17
5.2.10	Stability Design.....	17
5.2.11	Fluid Compatibility Design.....	17

5.2.12	Load, Acoustic, Shock, and Vibration Environment Design .....	17
5.2.13	Fracture Control Design .....	18
5.2.13.1	Damage Tolerance Life Design.....	18
5.2.13.2	Leak Before Burst Design .....	19
5.2.14	Fatigue Life Design .....	19
5.2.15	Reserved.....	19
5.2.16	Unique Operating Environments Design.....	19
5.2.17	Additional Design—Battery Containers .....	19
5.2.18	Additional Design—Cryostats and Dewars .....	19
5.2.19	Additional Design—Sealed Containers .....	19
5.2.20	Additional Design—Lines and Fittings.....	20
5.2.21	Additional Design—Pressurized Components .....	20
<b>5.3</b>	<b>Reserved .....</b>	<b>20</b>
<b>5.4</b>	<b>Materials.....</b>	<b>20</b>
<b>6</b>	<b>General Verification .....</b>	<b>20</b>
<b>6.1</b>	<b>Stability Verification.....</b>	<b>20</b>
<b>6.2</b>	<b>Fracture Control Verification .....</b>	<b>20</b>
6.2.1	Damage Tolerance Life Verification .....	20
6.2.2	Leak Before Burst Verification .....	21
<b>6.3</b>	<b>Unique Operating Environments Verification .....</b>	<b>21</b>
<b>7</b>	<b>Verification by Analysis .....</b>	<b>21</b>
<b>7.1</b>	<b>Metallic Material Properties.....</b>	<b>21</b>
<b>7.2</b>	<b>Reserved .....</b>	<b>22</b>
<b>7.3</b>	<b>Analysis Model.....</b>	<b>22</b>
7.3.1	Analysis Model – Strength .....	22
7.3.2	Analysis Model – Loads .....	23
7.3.3	Reserved.....	23
7.3.4	Reserved.....	23
7.3.5	Analysis Model – Stiffness.....	23
7.3.6	Analysis Model – Thermal Effects .....	23
<b>7.4</b>	<b>Pressurized Hardware Analysis.....</b>	<b>23</b>
7.4.1	Proof Pressure Analysis.....	23
7.4.2	Design Burst Pressure Analysis.....	23
7.4.3	Margin of Safety Analysis .....	23
7.4.4	Negative Pressure Differential Analysis .....	24
7.4.5	Stability Analysis.....	24
7.4.5.1	Linear Buckling Analysis .....	24
7.4.5.2	Nonlinear Buckling Analysis .....	25
7.4.6	Volume Capacity Analysis.....	25
7.4.7	Physical Envelope Analysis .....	25
7.4.8	Mass Analysis .....	25
7.4.9	Load, Acoustic, Shock, and Vibration Environment Analysis .....	25
7.4.10	Unique Operating Environments Analysis .....	25
7.4.11	Fluid Compatibility Analysis .....	25
7.4.12	Fatigue Life Analysis .....	26
7.4.13	Reserved.....	26
7.4.14	Reserved.....	26

7.4.15	Additional Analysis—Battery Containers .....	26
7.4.16	Additional Analysis—Cryostats and Dewars .....	26
7.4.17	Additional Analysis—Sealed Containers .....	26
7.4.18	Additional Analysis—Lines and Fittings .....	27
7.4.19	Additional Analysis—Pressurized Components .....	27
<b>7.5</b>	<b>Fracture Control Analysis .....</b>	<b>27</b>
7.5.1	Damage Tolerance Life Analysis .....	27
7.5.2	LBB Analysis .....	28
<b>7.6</b>	<b>Reliability Engineering Analysis .....</b>	<b>28</b>
7.6.1	Reliability Analysis .....	28
7.6.2	Failure Modes and Effects Analysis .....	28
<b>8</b>	<b>Manufacturing .....</b>	<b>29</b>
<b>8.1</b>	<b>Process Control .....</b>	<b>29</b>
<b>8.2</b>	<b>Corrosion Control and Fluid Compatibility .....</b>	<b>29</b>
<b>8.3</b>	<b>Embrittlement Control .....</b>	<b>29</b>
<b>8.4</b>	<b>Fabrication and Process Control .....</b>	<b>29</b>
<b>8.5</b>	<b>Reserved .....</b>	<b>29</b>
<b>9</b>	<b>Quality Assurance .....</b>	<b>29</b>
<b>9.1</b>	<b>QA Program Procedures .....</b>	<b>30</b>
<b>9.2</b>	<b>Quality Plan .....</b>	<b>30</b>
<b>9.3</b>	<b>Qualification Plan .....</b>	<b>30</b>
<b>9.4</b>	<b>Acceptance Plan .....</b>	<b>30</b>
<b>9.5</b>	<b>Inspection and Test Plan .....</b>	<b>30</b>
<b>9.6</b>	<b>Reserved .....</b>	<b>30</b>
<b>9.7</b>	<b>Quality Documentation .....</b>	<b>30</b>
<b>10</b>	<b>Verification by Test .....</b>	<b>31</b>
<b>10.1</b>	<b>Damage Tolerance Life Test .....</b>	<b>31</b>
10.1.1	Damage Tolerance Life Test—Coupon Specimens .....	31
10.1.2	Damage Tolerance Life Test—Pressurized Hardware Specimens .....	32
<b>10.2</b>	<b>LBB Test .....</b>	<b>33</b>
10.2.1	LBB Test—Coupon Specimens .....	33
10.2.2	LBB Test—Pressurized Hardware Specimens .....	33
<b>10.3</b>	<b>Reserved .....</b>	<b>34</b>
10.3.1	Reserved .....	34
10.3.2	Reserved .....	34
10.3.3	Reserved .....	34
10.3.4	Reserved .....	34
<b>10.4</b>	<b>Qualification Test .....</b>	<b>34</b>
10.4.1	Qualification Test Instrumentation .....	35
10.4.2	Nondestructive Testing .....	35
10.4.3	Physical Envelope Test .....	35
10.4.4	Mass Test .....	36
10.4.5	Volume Capacity Test .....	36
10.4.6	Proof Test .....	36
10.4.7	Leak Test .....	36
10.4.8	Pressure Cycle Test .....	36
10.4.9	Load, Acoustic, Shock, Vibration, and External Loads Test .....	36

10.4.10 Burst Test .....	37
10.4.11 Stability Test.....	37
10.4.12 Unique Operating Environments Test.....	37
10.4.13 Stiffness Test .....	37
<b>10.5 Validation of Analysis Model With Qualification Test Data .....</b>	<b>38</b>
<b>10.6 Acceptance Tests.....</b>	<b>38</b>
<b>11 Operations and Maintenance .....</b>	<b>39</b>
<b>11.1 Operating Procedures .....</b>	<b>39</b>
<b>11.2 Safe Operating Limits .....</b>	<b>39</b>
<b>11.3 Special Requirements for Pressurized Hardware .....</b>	<b>39</b>
<b>11.4 Embrittlement Control .....</b>	<b>39</b>
<b>11.5 Inspection and Maintenance .....</b>	<b>39</b>
<b>11.6 Material Review Board.....</b>	<b>40</b>
<b>11.7 Repair and Refurbishment .....</b>	<b>40</b>
<b>11.8 Storage .....</b>	<b>40</b>
<b>11.9 Operations Documentation .....</b>	<b>40</b>
<b>12 Documentation Retention.....</b>	<b>40</b>
<b>Annex (Informative) .....</b>	<b>42</b>

**List of Tables**

Table 1. Determination of Burst Factor, Proof Factor, Negative Pressure Factor, and Design Safety Factor .....	15
Table A. Design Requirements Verification Matrix .....	42

## Foreword

This version of S-080 was developed as an industry consensus to represent accepted practices for the design, analysis, fabrication, test, inspection, operation, and maintenance of metallic pressure vessels, pressurized structures, batteries, heat pipes, cryostats, dewars, sealed containers, accumulators, and pressure components such as lines, fittings, hoses, and bellows in space systems.

This version of S-080 was developed in collaboration with manufacturers, launch-site operators, range safety authorities, and individuals affiliated with universities and government entities.

The key elements in the revised version of this standard are as follows:

- Reformatted the requirements to align with ANSI/AIAA S-081B-2018, *Space Systems—Composite Overwrapped Pressure Vessels*
- Updated the requirements for design and verification including damage tolerance life (formerly referred to as safe life) and leak before burst
- Articulated the responsibility of the owner, manufacturer, and procuring authority
- Organized the requirements into separate sections for design, analysis, and test
- Added a design requirements verification matrix
- Added sections to identify the manufacturing, quality assurance, and operations and maintenance requirements
- Added requirements for maximum mass and required volume
- Expanded the requirements for stability and included a higher safety factor when verification is performed by analysis only
- Added requirements to address scenarios with significant combined loads
- Added an alternate set of requirements for lines and/or fittings with 1.5 inches (38 mm) outside diameter or greater
- Added requirements for quantifiable reliability and a failure modes and effects analysis
- Identified requirements associated with reuse
- Aligned sections to better identify the separate requirements for metallic pressure vessels, pressurized structures, batteries, heat pipes, cryostats, dewars, sealed containers, and pressure components such as lines, fittings, and hose made of metal
- Removed the thermal vacuum testing requirement for batteries and battery cases because they will be included in ANSI/AIAA S-136-201x, *Battery Safety Standard for Space Applications*
- Articulated requirements for data documentation
- Incorporated loading spectra into the service life

The AIAA Aerospace Pressure Vessels (APV) Committee on Standards (CoS) was initially formed in March 1996 as a working group within the AIAA Structures Committee on Standards with an emphasis on inclusion of aerospace prime companies, pressure vessel suppliers, and all applicable government agencies. Deliberations focused on adapting the standard to address commercial procurement of aerospace composite pressure vessels.

The current members of the AIAA APV CoS appreciate the valuable input from several original members, and express their gratitude to past committee members and reviewers whose contributions over many years



have resulted in an improved standard. At the time of approval of this document, members of the APV CoS were:

Michael Kezirian, Chair	University of Southern California
Nathanael Greene, Co-Chair	NASA Johnson Space Center
Alejandro Vega, Co-Chair	U.S. Air Force

Subcommittee Chairpersons:

Manoj Bhatia*	Keystone Engineering
Kevin Case	U.S. Department of Defense
Harry Conomos	Moog, Inc.
Owen Greulich	NASA Headquarters
Lorie Grimes-Ledesma	NASA Jet Propulsion Laboratory
Joe Hamilton	APT Research
Peter Kinsman	Aerojet Rocketdyne
Kirk Sneddon	Arde, Inc.
Mark Stevens	MEI Technologies
John Thesken*	NASA Glenn Research Center

Members:

Pravin Aggarwal*	NASA Marshall Space Flight Center
Joachim Beek*	NASA Johnson Space Center
Harold Beeson*	NASA White Sands Test Facility
Robert Biggs	Lockheed Martin Space Systems Company
Randy Brown*	Lockheed Martin Space Systems Company
Matt Buchholz*	MasterWorks Composite Solutions
Jim Chang	Analytical Mechanics Associates
Robert Conger	Microcosm, Inc.
John Duke, Jr.	Virginia Polytechnic Institute and State University
Amy Engelbrecht-Wiggans	Cornell University
Paul Fabian	Composite Technology Development, Inc.
Scott Forth	Spaceship Company
Susan Gavin	Independent Technical Advisor – Engineering Contractor
Wes Geiman	Vivace Corporation

Robert Geuther*	U.S. Air Force, 45th Space Wing
Vinay Goyal	The Aerospace Corporation
Jon Griffith	Blue Origin
Tim Gurshin*	Lockheed Martin Space Systems Company
Jim Harris	MasterWorks Composite Solutions
Luis Hernandez	GeoControls Systems Inc.
Mike Holt	Virgin Galactic
Kaiser Imtiaz	The Boeing Company
Sri Iyengar	United Launch Alliance
Michael Kelly	FAA/AST
Andre Lavoie	Virgin Galactic
Joseph Lewis*	NASA Jet Propulsion Laboratory
Edward Lira	U.S. Department of Defense
David McColskey	National Institute of Standards and Technology
Dan Mueller	Space Exploration Technologies Corporation
Cornelius Murray	General Dynamics/OTS
Norman Newhouse	Hexagon Lincoln
Yenyih Ni	The Aerospace Corporation
Jay Nightingale	Lockheed Martin Space Systems Company
Michael Papadopoulos*	The Aerospace Corporation
James Patterson	HyPerComp Engineering
Kevin Richards	Orbital ATK
Michael Robinson*	Boeing
Markus Rufer	Scorpius Space Launch Company
Rick Russell*	NASA Kennedy Space Center
Regor Saulsberry*	NASA White Sands Test Facility
Joseph Seidler	USAF, 45th Space Wing
Kay Siegel	H2Safe, LLC
Gerben Sinnema	European Space Agency
Brian Spencer*	Spencer Composites
Michael Surratt*	University of Southern California
Jim Sutter*	Independent Consultant

ANSI/AIAA S-080A-2018

Pete Taddie*	NASA Kennedy Space Center
Walter Tam*	ATK Space
Bruce Wallace	Boeing
Jess Waller	HX5, Inc.
Daniel Wentzel*	NASA White Sands Test Facility
Jerry Widmar	NASA Johnson Space Center
Paul Wilde*	Federal Aviation Administration
Steven Wilson	United Launch Alliance
Robert Wingate*	NASA Marshall Space Flight Center
Kamil Wlodarczyk	Orbital ATK
Tommy Yoder	NASA White Sands Test Facility

NOTE Names marked with an asterisk participated as Observer, nonvoting member.

The above consensus body approved this document in December 2017.

The AIAA Standards Executive Council (Allen Arrington, Chairperson) accepted the document for publication in March 2018.

The AIAA Standards Procedures dictates that all approved standards, recommended practices, and guides are advisory only. Their use by anyone engaged in industry or trade is entirely voluntary. There is no agreement to adhere to any AIAA standards publication and no commitment to conform to or be guided by standards reports. In formulating, revising, and approving standards publications, the committees on standards will not consider patents that may apply to the subject matter. Prospective users of the publications are responsible for protecting themselves against liability for infringement of patents or copyright, or both.

# 1 Scope

This standard establishes baseline requirements for the design, analysis, manufacturing, test, and operation of metallic pressurized hardware used for aerospace systems such as spacecraft and launch vehicles.

Requirements for metallic pressurized hardware levied from other authorities (such as Range Safety, FAA, DOT, etc.) may also be applicable. Specific applications, particularly those involving human spaceflight, may have additional requirements. There may also be additional requirements for hardware elements that are not addressed by this document, such as the presence of a propellant management device or diaphragm. The full set of these requirements should be identified before the design process begins and should be addressed through all stages of the lifecycle.

## 1.1 Purpose

These requirements are intended to assure the safety and enhance the success of the operation of metallic pressurized hardware in an aerospace system.

## 1.2 Applicability

This standard is applicable to metallic pressurized hardware. Included are metallic pressure vessels, pressurized structures, batteries, heat pipes, cryostats, dewars, sealed containers, accumulators, and pressure components such as lines, fittings, hoses, and bellows.

A companion standard, ANSI/AIAA S-081B Space Systems—Composite Overwrapped Pressure Vessels, is applicable to spaceflight composite overwrapped pressure vessels (COPVs).

## 1.3 Designation of Responsibilities

This section identifies the responsibilities for the key agents: owner, procuring authority, and manufacturer.

It is noted that the owner and procuring authority may be the same entity.

The procuring authority and the manufacturer may also be the same entity, in which case additional consideration should be given regarding independent oversight.

### 1.3.1 Owner

The owner establishes the system level requirements. The owner develops the aerospace system incorporating the metallic pressurized hardware to meet these system level requirements. The owner performs the system analysis on the aerospace system to identify the operational envelope, establishing the design requirements. The owner is responsible for determining the criticality of the aerospace system.

The owner is responsible for reviewing and approving any tailoring of requirements including the use of a document revision other than what is specified in Section 3.

The owner specifies options provided in the standard before contracting with the manufacturer. For example, the burst factor (Section 5.2.1) and design safety factor (Section 5.2.4) are established. In addition, for the conditions established in Section 5.1, there may be options for the design and verification approach (Section 6).

The owner has the responsibility for approving engineering source approved (ESA) processes and subsequent changes. The owner should solicit engineering input prior to accepting ESA process changes.

The owner may delegate any of the above authority and decision making responsibility to a procuring authority (typically an intermediate contractor or a consultant) but remains responsible for the overall system.