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Guide

Guide: Space Systems — Composite Overwrapped Pressure Vessels with a Plastic Liner

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Sponsored and Approved by

American Institute of Aeronautics and Astronautics

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Abstract

This Guide assists in establishing baseline requirements for the design, analysis, fabrication, test, inspection, operation, and maintenance of composite overwrapped pressure vessels (COPVs) with a plastic non-metallic liner. These COPVs are used for pressurized, hazardous, or nonhazardous liquid or gas storage in space systems including spacecraft and launch vehicles. This Guide is applicable to COPVs constructed with a plastic liner and a carbon fiber/polymer overwrap.

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Foreword

This Guide is sponsored by the American Institute of Aeronautics and Astronautics (AIAA) as part of its Standards Program.

This Guide was developed in collaboration with manufacturers, launch site operators, range safety authorities, and individuals affiliated with universities and government entities.

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 APV CoS in 2018 published: ANSI/AIAA S-080A-2018 Space Systems—Metallic Pressure Vessels, Pressurized Structures, and Pressure Components (Revision of AIAA S-080-1998) and ANSI/AIAA S-081B-2018 Space Systems—Composite Overwrapped Pressure Vessels (Revision of AIAA S-081A-2006). These two standards followed a consistent numbering; sections (requirements) that are common between the two have the same number in both documents. If one document has a section (requirement) that is not applicable (while it is relevant for the companion document) then the section is marked reserved to keep the numbering consistent. The same consistency has been followed in this Guide with respect to the two other standards.

ANSI/AIAA S-081B-2018 is applicable to COPVs constructed with a metal liner and a carbon fiber/polymer overwrap. The incorporation of a non-metallic liner changes the approach to certifying this class of COPVs and necessitates a distinct set of baseline requirements. Because the technology associated with the use of these COPVs has not been used extensively in space applications, the AIAA Aerospace Pressure Vessel Committee on Standards decided to develop this Guide in order to establish the framework for such requirements. It is hoped that this Guide will develop into a standard as the industry adopts the usage of these vessels and a consensus set of requirements emerged.

The AIAA Standards Program Procedures defines a Guide as:

> technical information that supports present or future Standards or Recommended Practices and provides instruction for their application; this category includes handbooks and uses “may” statements, indicating a permissive position

In this Guide, the requirements that are retained from ANSI/AIAA S-081B-2018 are indicated with Asterisks, i.e., they are expressed as ‘*may’ statements. It is noted that ANSI/AIAA S-080A-2018 and ANSI/AIAA S-081B-2018 follow the same document structure, so this Guide matches the organization of these two standards.

The Guide includes new sections to provide guidance for establishing design and verification requirements related to the non-metallic liner.

In general, the committee chose not to update sections of the document not affected by the change of the liner material. In some areas, it was felt necessary to offer improvements based on experience. The following changes to baseline requirements are included:

- Additional clarification was provided for the use of the Environmental Correction Factor (ECF).
- Definitions were updated. Definitions were added for liner, hydrogen embrittlement, and glass transition temperature.
- Requirements for reliability were added as they appear to be an error in the previous standards.

It is anticipated that these changes might later be incorporated into future revisions of ANSI/AIAA S-080A-2018 and ANSI/AIAA S-081B-2018.

We are indebted to those authors who served on the Drafting Committee and compiled the input from a broad range of stakeholders to form the various drafts for review by the committee: Jim Harris (Editor/Chair), Jacob Fannon, Scott Forth, Vinal Goyal, and Michael Kezirian.

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:

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

The above consensus body approved this document on 16 September 2022.

The AIAA Standards Steering Committee (Paul Lambertson, Chair) accepted the document for publication on 6 December 2022.

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1 Scope

This Guide provides guidance for establishing baseline requirements for the design, analysis, manufacturing, test, and operation of composite overwrapped pressure vessels (COPV) with a plastic liner used for aerospace systems such as spacecraft and launch vehicles. This Guide is only applicable for a COPV with a plastic liner; the liner includes the metallic portions such as the bosses.

Requirements for COPVs 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 may be identified before the design process begins and may be addressed through all stages of the lifecycle.

1.1 Purpose

This guidance for establishing requirements is intended to assure the safety and enhance the success of the operation of a COPV in an aerospace system.

1.2 Applicability

This Guide is applicable only to COPVs containing a plastic liner and constructed with a carbon fiber/polymer matrix overwrap. Applicable plastic liners are comprised of thermoset or thermoplastic polymer material and includes a metallic boss.

COPVs that include a fiberglass overwrap layer that serves only to protect the vessel from impact damage are permitted.

There are two companion standards to this Guide: ANSI/AIAA S-080A Space Systems—Metallic Pressure Vessels, Pressurized Structures, and Pressure Components and ANSI/AIAA S-081B-2018 Space Systems—Composite Overwrapped Pressure Vessels.

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 may be given regarding independent oversight.

1.3.1 Owner

The owner establishes the system level requirements. The owner develops the aerospace system incorporating the COPV 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 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 Guide 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 5.2.10, there may be options for the liner design and verification approach (Section 6.1).

The owner is responsible for recognizing the certification of trained COPV visual inspectors and the approval and implementation of the Inspection and Test Plan (ITP), including accept and reject criteria of necessary inspections and the creation and adherence to the Damage Control Plan (DCP).