

**Proposed Draft Ground Safety
Requirements for COPV and Composite
Pressure Structures (CPS) for Inclusion
in AIAA S-081 and AIAA S-089**

COPV and CPS ground safety requirements are needed to help prevent the following from happening again



Types of CPSs at KSC

Future Responsive Access to
Space Technology (FAST)
pathfinder experiment.



CRYO CPS before accident.

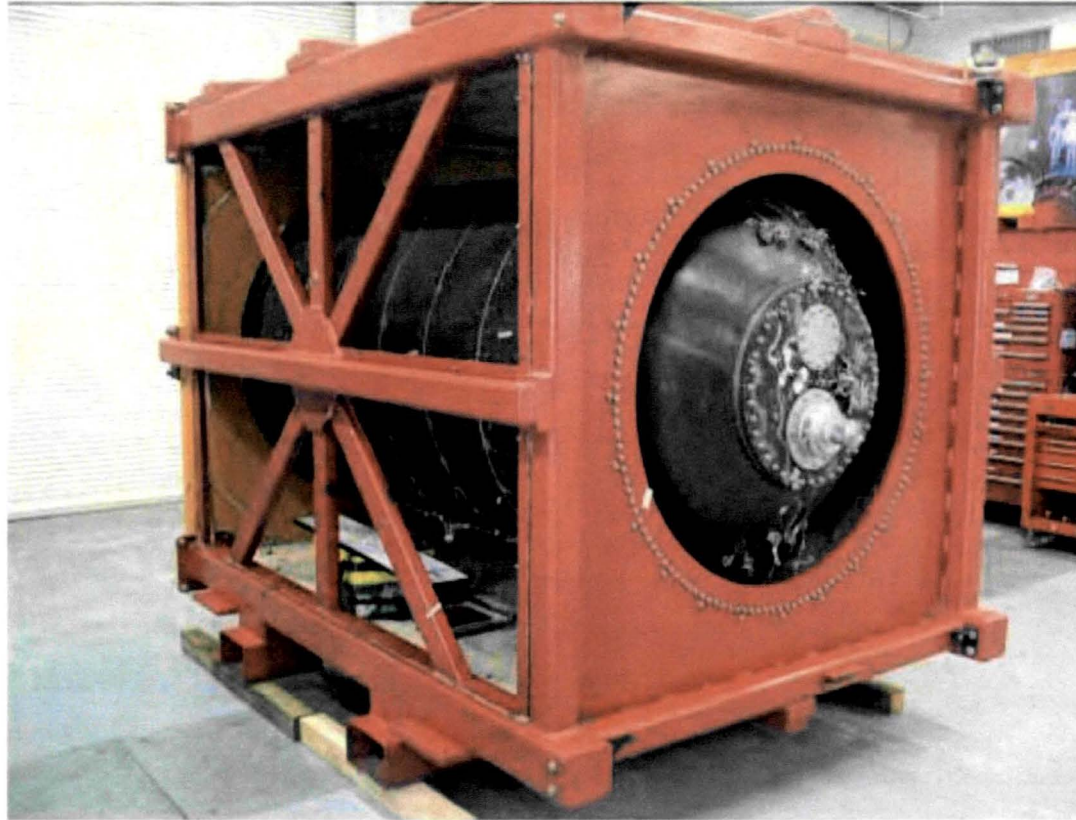


Figure 2-2. Composite Tank in Support Structure

Proposed COPV Ground Processing Requirements

Revised COPV Ground Processing Requirements based on the Feb 8 2011 Composite Pressure Vessel Ground Processing Safety Requirements TIM at KSC.

SAFETY REQUIREMENTS FOR DESIGN, TEST, AND GROUND PROCESSING OF FLIGHT COMPOSITE OVERWRAPPED PRESSURE VESSELS (COPVs) AT THE KENNEDY SPACE CENTER (KSC)

- a. The hardware provider shall verify that the design, qualification, and acceptance testing of the COPV-complies with the requirements of ANSI/American Institute of Aeronautics and Astronautics (AIAA) S-081 Space Systems-Composite Overwrapped Pressure Vessels (COPVs) or another industry recognized standard for COPVs.
- b. Prior to the first pressurization of a COPV at KSC an inspection of the vessel for visible damage shall be performed by a trained inspector. ~~The trained inspector" skills shall be comparable to a Level II visual inspector, per the American Society for Nondestructive Testing (ASNT) Recommended Practice No. SNT TC 1A (see ANSI/AIAA S-081A-2006, Paragraph 5.5.3).~~ The Inspector must be trained in the specific inspection of COPV's. This training must address the types of damage that can occur the effects of that damage, and disposition of damage indications. Currently this training is conducted by NASA White Sands Test Facility.

Definition of Trained Inspector: (COPV) - A person trained specifically in the detection of visual damage of COPVs and familiarized with the NDE methods and results that could be used to aid in the interpretation of visual damage. White Sands Test Facility typically conducts this training as part of their COPV damage control and inspection course.

(JBH Note We have not yet been able to create wording that would could apply both to NASA and non NASA Aerospace companies)

If this inspection is not possible at the launch site (i.e. COPV is not accessible), then it shall be conducted the last time the COPV is accessible for inspection.

- c. The Mechanical Damage Control Plan (MDCP) for the COPV shall be provided by the hardware provider and made available for review by the applicable KSC safety organization. This COPV damage control plan shall evaluate and mitigate the threats during shipping and handling, assembly level integration, ground processing, and launch vehicle integration. Guidance for a COPV MDCP are in AIAA-S-081 and NASA Memo ES4-10-021 Damage Control Plan Template for Composite Overwrapped Pressure Vessels

Proposed COPV Ground Processing Requirements

- d. (JBH note As an action from the Feb 8 2011 TIM, Lorie Grimes-Ledesma and I reviewed the 1994 Amos Alexander memo justifying the 1.1 test and the Annex B document. We issued a memo stating “Given the above it was our opinion that there is no longer sufficient reason to keep the 1.1 pressurization test requirement in future NASA COPV ground safety requirements.”)
- e. If COPVs are to be pressurized at KSC to pressures greater than one third of the COPVs design burst pressure, the pressurizations shall be performed remotely, ensuring ground personnel safety or a blast shield shall be used to protect personnel. If the vessel is to remain pressurized, personnel access shall not be permitted to the area for at least ten (10) minutes after pressurization is completed.
- f. Personnel limits for each operation on or near the COPV shall be established to minimize personnel exposure to the pressurized tank when at pressures greater than one third design burst pressure. If the COPV is pressurized above 1/3 design burst, the safety clear distance during pressurization and the post pressurization personnel access controls shall be determined by a COPV blast/fragmentation analysis.
- g. The transport of pressurized COPVs at pressures greater than one third design burst pressure shall be along routes that minimize exposure to personnel and facilities with escort during designated “off-shift” time periods.
- h. Hardware providers shall develop Emergency Response Plans (ERPs) that include contingency safing and backout plans for COPVs. The ERPs shall consider leaks, impact damage to the COPV that requires immediate action, and exposure to hazardous materials including graphite fibers if applicable. If implemented, a real-time assessment shall be accomplished and contingency operations taken as required. The ERP shall be approved prior to the start of ground operations by the applicable NASA Safety organization.

**PROPOSED GROUND PROCESSING SAFETY REQUIREMENTS
FOR DESIGN, TEST, AND GROUND PROCESSING OF COMPOSITE
PRESSURIZED STRUCTURE (CPS) AT THE KENNEDY SPACE
CENTER (KSC)**

Proposed CPS Ground Processing Requirements

- a. The CPS provider shall provide to the appropriate KSC safety organization either
- 1) documentation verifying that the design, qualification, and acceptance testing of the CPS complies with the requirements of the current relevant Industry standard or code, such as ANSI/American Institute of Aeronautics and Astronautics (AIAA) S-089 Space Systems – Composite Pressurized Structure (CPS) when released.
 - or 2) documentation verifying the CPS meets another recognized relevant industry standard such as MIL-STD 1522A
 - or 3) state the CPS does not meet any recognized industry standard for CPS and provide as a minimum the following documentation

Damage Control Plan including storage and transportation requirements

Minimum design burst value. Provide burst test data validating the minimum design burst value

MEOP based on an analysis of the operational scenarios at KSC.

Assumed factor of safety based on stress ratio or pressure ratio (MDP/ MEOP)

Any MRB actions

Composite Visual Inspection with NDE reports with adverse results

Blast Analysis (if to be pressurized above 1/3 design burst pressure). If the CPS is to be pressurized above 1/3 design burst, provide recommended personnel access restrictions and safety clears based on a blast/fragmentation analysis.

Complete safety data package containing all the above plus any other safety related relevant CPS provider documentation such as an (Operation and Configuration Control Plan.

System Specifications:

Internal Volume: XXX liters

Rated fluids: XXX, plus all inert gases and nitrogen

Maximum Operating Pressure (MOP): XXXX psia

Maximum Design Pressure (MDP): XXX psia

Proof Pressure Factor of Safety: XXX

Proof Pressure: XXX psia

Design Burst Pressure Rating: XXX psia

Qualification Burst Pressure: XXX psia

Proposed CPS Ground Processing Requirements

b. Prior to the first pressurization of a CPS at KSC an inspection of the vessel for visible damage shall be performed by a trained inspector. ~~The trained inspector's skills shall be comparable to a Level II visual inspector, per the American Society for Nondestructive Testing (ASNT) Recommended Practice No. SNT-TC-1A (see ANSI/AIAA S-081A-2006, Paragraph 5.5.3).~~ The Inspector must be trained in the specific inspection of CPSs. This training must address the types of damage that can occur the effects of that damage, and disposition of damage indications. Currently this training is conducted by NASA White Sands Test Facility.

Add Definition of Trained Inspector: (CPS) A person trained specifically in the detection of visual damage of CPSs and familiarized with the NDE methods and results that could be used to aid in the interpretation of visual damage. White Sands Test Facility typically conducts this training as part of their CPSs damage control and inspection course.

(JBH note WSTF may teach an updated COPV damage control and inspection course or an addendum covering CPS inspection)

(JBH Note We have not yet been able to create wording that would could apply both to NASA and non NASA Aerospace companies)

If this inspection is not possible at the launch site (i.e. the CPS is not accessible), then it shall be conducted the last time the CPS is accessible for inspection.

Proposed CPS Ground Processing Requirements

- c. If CPSs are to be pressurized at the KSC to pressures greater than one third of the CPS design burst pressure or loaded to more than $\frac{1}{3}$ the CPS limit load, the pressurizations/loading shall be performed remotely or a blast shield shall be used to protect personnel. The personnel access restrictions and blast shield design must be validated by a blast/fragmentation analysis that considers all possible CPS rupture energy source contributors. Pressurization of cryogenic/liquid gases shall evaluate the possibility of a boiling or BLEVE in the event of pressure vessel rupture. If the vessel is to remain pressurized, personnel access shall not be permitted to the area for at least ten (10) minutes after pressurization is completed.
- d. If propellants and other reactive commodities are to be used with a CPS with no liner, the hardware provider shall provide data on the compatibility testing and analysis of the composite and commodity for the possible range of pressures and temperatures encountered during ground processing and storage.
- e. Personnel limits for each operation on or near the CPS shall be established to minimize personnel exposure to the pressurized tank when at pressures greater than one third design burst pressure or loaded to more than $\frac{1}{3}$ the CPS limit load, based on an appropriate blast/fragmentation or an appropriate QD siting analysis.

Proposed CPS Ground Processing Requirements

- f. The transport of pressurized CPSs at pressures greater than one third design burst pressure shall be along routes that minimize exposure to personnel and facilities with escort during designated “off-shift” time periods.
- g. The Mechanical Damage Control Plan (MDCP) for the CPS shall be provided by the hardware provider and made available for review by the applicable KSC Safety organization. This CPS damage control plan shall evaluate and mitigate the threats during shipping and handling, assembly level integration, ground processing, and launch vehicle integration. Guidance for a COPV MDCP is in NASA Memo ES4-XX-xxx Damage Control Plan Template for Composite Pressurized Structures and AIAA S-089 Space Systems – Composite Pressurized Structure (CPS).
- h. If propellants and other reactive commodities are to be used with a CPS without a metal liner, the hardware provider shall provide data on the compatibility testing and analysis of the composite and commodity for the possible range of pressures and temperatures encountered during ground processing and storage.
- i. Hardware providers or users shall develop Emergency Response Plans (ERPs) that include contingency safing and backout plans for CPSs. The ERPs shall consider leaks, impact damage to the CPS that requires immediate action, and exposure to hazardous materials including graphite fibers if applicable. If implemented, a real-time assessment shall be accomplished and contingency operations taken as required. The ERP shall be approved prior to the start of ground operations by the applicable NASA Safety organization.