Quality Assurance Impacts On Flight Pressure Systems

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Agenda

U.S. Military, Civil, and Commercial Aviation and Space share common interest that depend on robust Quality Systems to reduce risk and ensure **Flight and Ground Safety, as well as Mission Success**

- Quality Systems
- Flight Pressure Vessels
- Quality Impacts on Safety
- Future QA Challenges that Affect Safety

Quality Systems

Who is responsible for Quality?

We All Are

What does Quality mean to you?

Quality means compliance with descriptions of intent. These may be found in *technical specifications* that describe *form, fit, and function*, or in procedures that describe *how personnel or equipment must progress through various action.*

Where can Quality be found?

Quality can be found in a minimal criteria for *certification or accreditation.* The measure of Quality may be in test or inspection results, process controls, data logs, audit records or records of completed work sequences.

When and How does Quality Impact Safety?

Quality Systems

NASA Quality assures compliance of manufactured and test items, test equipment, facilities of manufacturing processes, and management systems through the implementation of a risk-based Quality program that accounts for the **criticality of the mission, systems, subsystems, components, subassemblies, parts and material,** and the *likelihood and severity of consequences* if compliance is not achieved.

Flight Pressure Vessels

Pressure Vessels used on aircraft and spacecraft come in all shapes, sizes, construction methods, and fabrication techniques. Design, fabrication, testing, inspection, processing, and handling requirements are regulated and controlled by adherence to government and industry standards and practices, e.g., Space Force/Air Force/NASA-standards, AIAA, DOT, ISO, ESA,…

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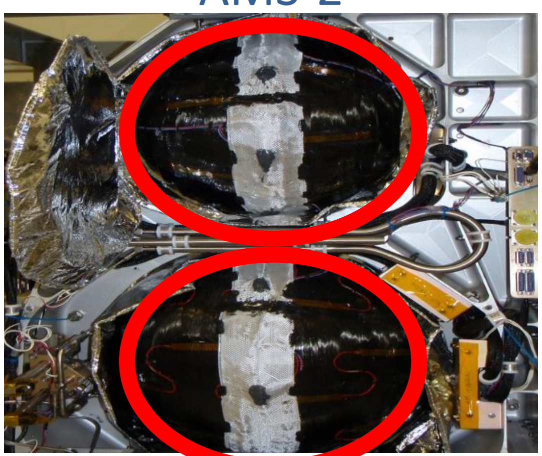

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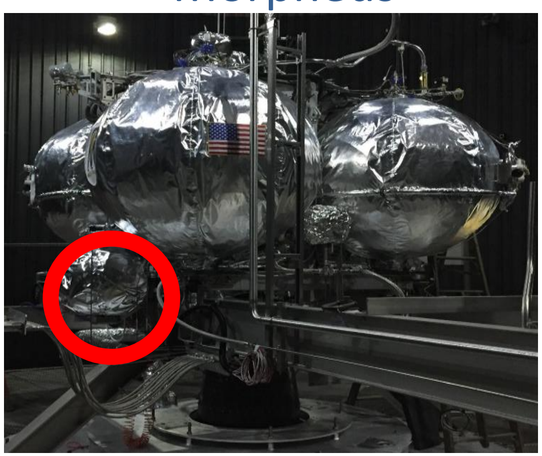


Flight Pressure Vessels

Classificati on	Construction	Typical % of Load (liner)	Typical % of Load (composite)
Type I	All metal	100	N/A
Type II	Metal liner with only composite hoop wrap	50	50
Type III	Metal liner fully wrapped with composite	10	90
Type IV	Polymeric liner fully wrapped with composite	N/A	100
Type V	Liner-less fully wrapped with composite	N/A	100

Flight Pressure Vessels

Composite Overwrap Pressure Vessels (COPVs)

- Advances in technology of Pressure Vessels have been a game changer in the U.S. Aerospace industry

- Advances in Flight Pressure System design, material, and fabrication techniques, have led the way in the creation of COPV technologies

- Advances allowed **significant savings in vehicle weight reduction, mission cost, manufacturing times, improvements in reliability, as well as processing and handling of vehicles and subsystems**

Flight Pressure Vessels

COPVs support commercial and government (military and civil) aeronautics, and aerospace applications

- Complex structure – various materials used to construct a component
  - Liner – prevents leakage and may or may not carry loads
  - Reinforcement Fiber – over wrapped fiber material providing most or all the strength
  - Resin System – provide for load sharing and minor protection

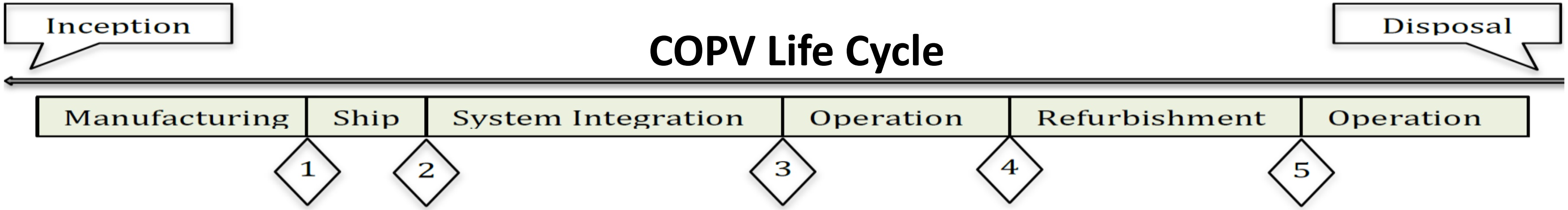
- The weight of COPVs are half as heavy as metallic pressure vessels designed to the operate at the same service pressure
- Designed to hold and dispense liquid or gas under pressure
- *COPVs are more expensive and require Fracture Critical Life Cycle Quality Assurance- specialized inspection, fabrication, shipping, integration, pressurization, and storage and documentation*

Quality Impacts On Safety

- COPVs are Fracture Critical Flight Hardware
  - **Life Cycle Fracture Control** is required to address the risk of failure associated with cracks in both the fiber and metallic liners

- COPVs are Susceptible to Mechanical Impact Damage
  - Life Cycle Threat Assessments and Inspection requirements
    - **NASA requires Per Program/Project Damage Control Plans (DCP) and Mechanical Damage Control Plans (MDCP)**
      - Credible Threats, Mitigations to Threats and Inspection points
      - Life Cycle (cradle to grave)
    - **Quality Inspection requirements must flow down through every phase of a COPV Life Cycle- work documents, procedures, and support contracts**
  - Ensure COPV inspector's knowledge, skills, and ability based on documented training, experience, and **certification requirements.**
    - Per AIAA, NASA, AF or other applicable codes, and/or standards

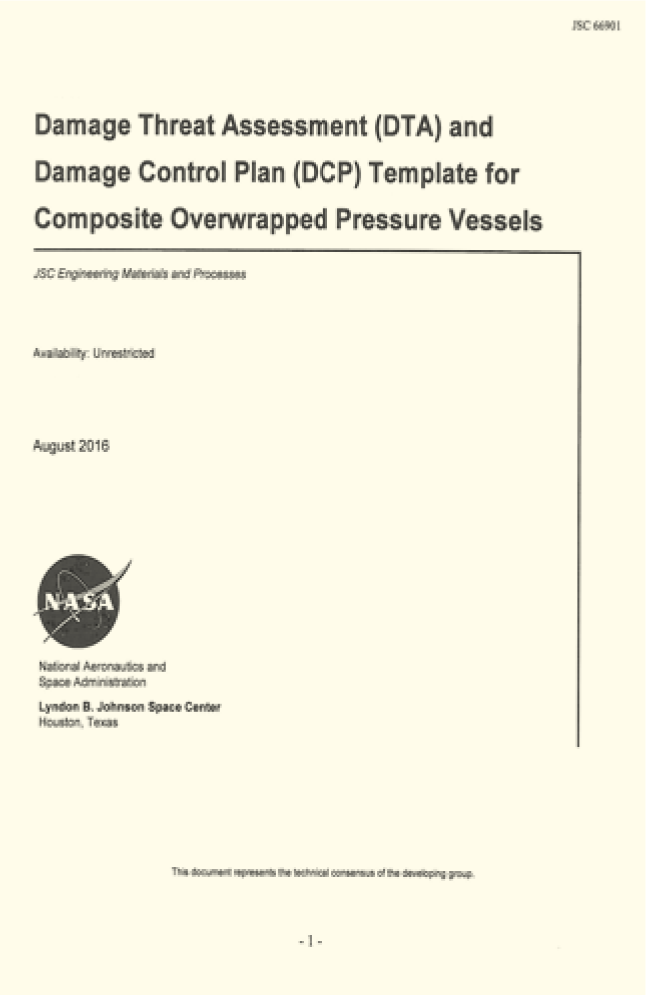
Quality Impacts On Safety



- AIAA S-081
  - training, silent on certification
- AIAA S-081A and S-081B
  - Certification, i.e., written practice documentation (SNT-TC-1A or NAS 410)
- AFSPCMAN 91-710 (V3 2019)
- NASA-STD-8715.1 and 8719.24
- KNPR 8715
- JSC 66901-DCP
  - WJI-LFACMGMT-0076D
  - WSTF Web-Paper Doc # 111102
- MSFC-RQMT-3479

Quality Impacts On Safety

Program Damage Control Plans define the **credible damage threats** to a COPV during its Life Cycle to include ***manufacturing, handling, test, storage, transportation, in-service use and maintenance, including integration, launch, re-entry, landing and re-flight,*** as applicable, the steps taken to mitigate against the possibility of damage due to these threats and the **identification of visual inspection points.**


JSC 66901

Damage Threat Assessment (DTA) and Damage Control Plan (DCP) Template for Composite Overwrapped Pressure Vessels

JSC Engineering Materials and Processes

Availability: Unrestricted

August 2016

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center
Houston, Texas

This document represents the technical consensus of the developing group.

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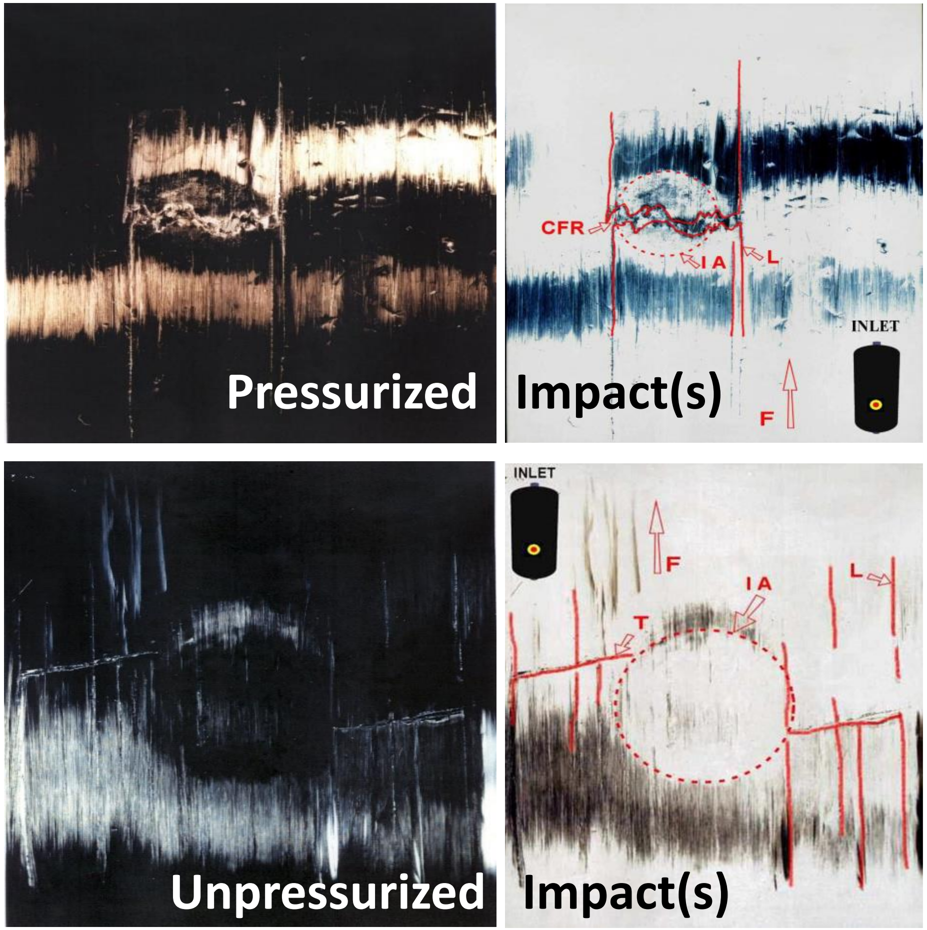
Quality Impacts On Safety

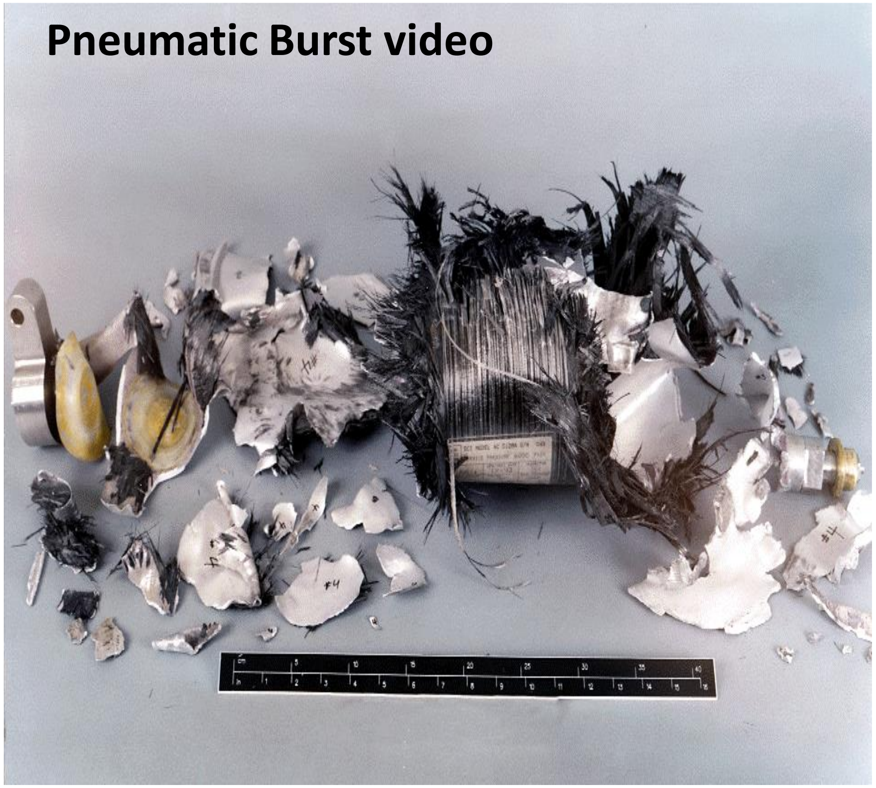
The effects of Mechanical Impact to Overwrap of COPV

- Pressurized during impact
  - Localized “crushed” resin
  - Cracked fiber inside of impact site location
  - **Hydraulic and/or Pneumatic charged**
- Unpressurized during impact
  - Cracked fiber extending out from dent



Quality Impacts On Safety

Differences in Fragmentation caused by a Hydrostatic Burst versus a Pneumatic Burst



Future QA Challenges that Affect Safety

COPV QA requirement flows are complexed and multifaceted

- Life Cycle
  - Requirement flow-down from Manufacturers to System Integrators, Ground Test, Vehicle Providers, ***Launch Site Service Providers***, and Launch Providers extending to Retrieval and Reuse
  - Satisfying Damage Tolerance Life, AIAA S-080 and S-081
  - Generations of effective Life Cycle Damage Control Plan
    - Ground Processing
    - Reusability
- Double Wall Radiographic inspections of liner welds
- Delivery and integration of uncertified PVs in certified vehicles
- Uncertified COPV inspectors inspecting certified hardware

Future QA Challenges that Affect Safety

- **Changing Requirements**
  - Human rated missions accepting non- human rated spaceflight rational to qualify COPVs for future flight
    - Reduction of System Fault Tolerances
    - Lower Factors of Safety and Higher Stress Ratios
    - Reductions in Burst and Proof Factors
    - Reductions in Fracture Control Requirements
  - Application of dated standards for COPV inspector qualifications
    - Trained vs Certified
- **Quality Assurance - Long Duration Missions**
  - High Purity Hydrogen Peroxide
- **Emerging COPV Technology**
  - COPV Type IV and V (liner-less) standards
  - New Material Systems
  - Additive Manufacturing Parts

Quality Assurance Impacts On Flight Pressure Systems