

Laboratories facts

COPV Damage Detection Course

The NASA White Sands Test Facility (WSTF) Damage Detection Course

provides comprehensive working knowledge of composite overwrapped pressure vessel (COPV) technology. The course is based on WSTF experience with pressure vessel testing and analysis developed since the inception of the technology in the 1970s. It has a specific focus on mechanical damage and propellant/fuel exposure effects on pressure vessels built using graphite/epoxy (Gr/Ep) composite filament wound onto metallic liners. Composed of both theory and practical instruction, the course covers damage characterization and detection, safety aspects of composite pressure vessels, and intensive hands-on inspection of flight COPVs with various levels of damage.

The COPV Damage Detection Course is recommended for all personnel involved in composite pressure vessel technology including:

- Safety Inspectors
- Quality Inspectors
- Engineers
- Integrators
- Program Managers
- Component & System Users
- Manufacturer's Personnel

Course Requirements

COPVs are replacing all metal pressure vessels in virtually every aerospace pressurized storage application. Numerous consensus standards and range documents exist that require visual inspections of COPVs by trained visual inspectors. These documents include:

- ANSI/AIAA S-081A: Space Systems - Composite Overwrapped Pressure Vessels
- Kennedy NASA Procedural Requirements (KNPR) 8715.3 (Latest Rev)
- Air Force Space Manual (AFSPCMAN) 91-710, Vol 3 & 6 (July 2004)
- Interim Policy Letter dated 23-Nov-1993: Interim Safety Requirements for Design, Test, Ground Processing of Flight Graphite Epoxy (Gr/Ep) Composite Overwrapped Pressure Vessels (COPVs) at the Kennedy Space Center (KSC), Cape Canaveral Air Force Station (CCAFS), and Vandenberg Air Force Base (VAFB)
- ECSS-E-ST-32-02C Rev. 1: European Cooperation for Space Standardization: Space engineering: Structural design and verification of pressurized hardware
- ISO 14623: International Standard: Pressure vessels and pressurized structures - Design and operation

This course satisfies the baseline requirements for trained visual inspectors for damage to carbon/epoxy composite overwrapped pressure vessels. It is an integral part of the typical COPV manufacturer and/or end user's inspector certification program. The WSTF COPV Damage Detection Course far exceeds the expectations of baseline training by providing additional education in the overall technology of COPVs. The only course recognized by industry to meet training requirements, it provides hands-on training on the largest number of flight-qualified vessels and vessels from nearly every manufacturer are represented during the hands-on portion.



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Course Outline

This intensive two-day course, divided into multiple sections, covers all COPV technology. To customize the learning experience, the course opens with discussion about the general education level and needs of course participants. Manufacturing techniques are discussed, from the manufacturing of the base fiber to the liners, and the filament winding of the final component, conveyed by numerous cross-sectioned samples and winding videos. The United States Air Force (USAF) NASA program data for mechanical damage, sustained load, and material compatibility is reviewed. In the impact control section, requirements of the damage control plan, conduction of a credible threat analysis, and elements of meeting damage control and protection are covered. Additional protection schemes demonstrate the importance of COPV protection during all phases of processing; even including shipping containers before the vessel is integrated to the vehicle, as well as the protective covers used post-integration. Complementary nondestructive evaluation (NDE) techniques investigated during the USAF/NASA program are discussed, along with new and emerging techniques. Laboratory sessions cover available NDE techniques, the photo reference guide, and an instructor's walkthrough of a visual inspection. Field inspections of program-damaged flight-qualified COPVs are conducted with groups of two performing detailed visual inspections on as many as ten COPVs in field-like environments concluding with a review of the findings and an in-depth discussion of results. This combination of techniques provides a well-rounded understanding of the technology and qualification to perform visual inspections of Gr/Ep COPVs.

Attendees will receive a course handbook, a CD of the course material, and an inspection kit with a variety of tools to aid in COPV visual inspection.

COPV Damage Detection Course Objectives & Content

Day One

- Terminology and Acronyms
- Manufacturing
 - Fiber production
 - Component production
- Overview of COPV Damage Mechanisms
 - COPV in the undamaged condition
 - Failure mode/safe-life of undamaged COPVs
 - Effects of impact damage
 - Stress rupture
 - Material compatibility
- Overview of Impact Control
 - Threat analysis
 - Visual damage threshold
 - Impact control plan
- Overview of Impact Protection
 - Shipping containers
 - Indicator covers
 - Hard-shell laminate covers
- Overview of COPV Inspection Techniques
 - Visual, X-Ray, Ultrasonic, Eddy Current, Acoustic Emission
 - Flash/Infrared Thermography and Laser Shearography

Day Two

- Receiving and Periodic Inspections
 - Visual inspection
 - X-ray of liner
 - Record requirements
- Laboratory Session
 - IR Thermography
 - Acoustic Impedance Testing
 - Thermal deply analysis and results
- Laboratory Sessions
 - Types of defects, origins, and significance
 - Manufacturing anomalies
 - Impact damage and variables
- Field Training Sessions: COPV Visual Inspection
 - Multiple damaged FLIGHT COPVs
 - Numerous damage levels and types
 - Normal manufacturing indications
- Course Completion
 - Certificate of course completion
 - Confidence to assess actual COPV damage