



Standard Guide for Nondestructive Testing of the Composite Overwraps in Filament Wound Pressure Vessels Used in Aerospace Applications¹

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1. Scope

1.1 This guide discusses current and potential nondestructive testing (NDT) procedures for finding indications of discontinuities and accumulated damage in the composite overwrap of filament wound pressure vessels, also known as composite overwrapped pressure vessels (COPVs). In general, these vessels have metallic liner thicknesses less than 2.3 mm (0.090 in.), and fiber loadings in the composite overwrap greater than 60 percent by weight. In COPVs, the composite overwrap thickness will be of the order of 2.0 mm (0.080 in.) for smaller vessels and up to 20 mm (0.80 in.) for larger ones.

1.2 This guide focuses on COPVs with nonload-sharing metallic liners used at ambient temperature, which most closely represents a Compressed Gas Association (CGA) Type III metal-lined composite tank. However, it also has relevance to 1) monolithic metallic pressure vessels (PVs) (CGA Type I), 2) metal-lined hoop-wrapped COPVs (CGA Type II), 3) plastic-lined composite pressure vessels (CPVs) with a nonload-sharing liner (CGA Type IV), and 4) an all-composite, linerless COPV (undefined Type). This guide also has relevance to COPVs used at cryogenic temperatures.

1.3 The vessels covered by this guide are used in aerospace applications; therefore, the inspection requirements for discontinuities and inspection points will in general be different and more stringent than for vessels used in non aerospace applications.

1.4 This guide applies to 1) low pressure COPVs used for storing aerospace media at maximum allowable working pressures (MAWPs) up to 3.5 MPa (500 psia) and volumes up to 2 m³ (70 ft³), and 2) high pressure COPVs used for storing compressed gases at MAWPs up to 70 MPa (10,000 psia) and volumes down to 8000 cm³ (500 in.³). Internal vacuum storage or exposure is not considered appropriate for any vessel size.

1.5 The composite overwraps under consideration include but are not limited to ones made from various polymer matrix resins (for example, epoxies, cyanate esters, polyurethanes, phenolic resins, polyimides (including bismaleimides), and polyamides) with continuous fiber reinforcement (for example, carbon, aramid, glass, or poly-(phenylenebenzobisoxazole) (PBO)). The metallic liners under consideration include but are not limited to aluminum alloys, titanium alloys, nickel-chromium alloys, and stainless steels.

1.6 This guide describes the application of established NDT methods; namely, Acoustic Emission (AE, Section 7), Eddy Current Testing (ECT, Section 8), Laser Shearography (Section 9), Radiologic Testing (RT, Section 10), Thermographic Testing (TT, Section 11), Ultrasonic Testing (UT, Section 12), and Visual Testing (VT, Section 13). These methods can be used by cognizant engineering organizations for detecting and evaluating flaws, defects, and accumulated damage in the composite overwrap of new and in-service COPVs.

NOTE 1—Although visual testing is discussed and required by current range standards, emphasis is placed on complementary NDT procedures that are sensitive to detecting flaws, defects, and damage that leave no visible indication on the COPV surface.

NOTE 2—In aerospace applications, a high priority is placed on light weight material, while in commercial applications; weight is typically sacrificed to obtain increased robustness. Accordingly, the need to detect damage below the visual damage threshold is more important in aerospace vessels.

NOTE 3—Currently no determination of residual strength can be made by any NDT method.

1.7 All methods discussed in this guide (AE, ET, shearography, RT, TT, UT, and VT) are performed on the composite overwrap after overwrapping and structural cure. For NDT procedures for detecting discontinuities in thin-walled metallic liners in filament wound pressure vessels, or in the bare metallic liner before overwrapping; namely, AE, ET, laser profilometry, leak testing (LT), penetrant testing (PT), and RT; consult Guide E2982.

1.8 In the case of COPVs which are impact damage sensitive and require implementation of a damage control plan, emphasis is placed on NDT methods that are sensitive to

¹ This test method is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.10 on Specialized NDT Methods.

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