

October 16, 2012



U.S. Department
of Transportation

East Building, PHH-30
1200 New Jersey Avenue, Southeast
Washington, D.C. 20590

**Pipeline and Hazardous
Materials Safety Administration**

DOT-SP 15415

EXPIRATION DATE: September 30, 2014

(FOR RENEWAL, SEE 49 CFR § 107.109)

1. GRANTEE: Vexxel Composites LLC
Brigham City, UT
2. PURPOSE AND LIMITATIONS:
 - a. This special permit authorizes the manufacture, mark, sale and use of a non-DOT specification fully wrapped, carbon-fiber reinforced, aluminum lined cylinder, designed in accordance with the ISO 11119-2 standard except as specified herein, for the transportation in commerce of the materials authorized by this special permit. This special permit provides no relief from the Hazardous Materials Regulations (HMR) other than as specifically stated herein. The most recent revision supersedes all previous revisions.
 - b. The safety analyses performed in development of this special permit only considered the hazards and risks associated with transportation in commerce. The safety analyses did not consider the hazards and risks associated with consumer use, use as a component of a transport vehicle or other device, or other uses not associated with transportation in commerce.
3. REGULATORY SYSTEM AFFECTED: 49 CFR Parts 106, 107 and 171-180.
4. REGULATIONS FROM WHICH EXEMPTED: 49 CFR § 49 CFR Parts 106, 107, and 171-180
5. BASIS: This special permit is based on the application of Vexxel Composites LLC dated November 1, 2011, and additional information dated June 7, 2012, July 20, 2012 and August 29, 2012, submitted in accordance with § 107.105 and the public proceeding thereon.

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6. HAZARDOUS MATERIALS (49 CFR § 172.101):

Hazardous Material Description			
Proper Shipping Name	Hazard Class/ Division	Identification Number	Packing Group
Air, compressed	2.2	UN1002	N/A
Argon, compressed	2.2	UN1006	N/A
Carbon dioxide	2.2	UN1013	N/A
Nitrogen, compressed	2.2	UN1066	N/A
Oxygen, compressed	2.2	UN1072	N/A

7. SAFETY CONTROL MEASURES:

a. PACKAGING - The prescribed packaging is a non-DOT specification fully wrapped, carbon-fiber reinforced, aluminum lined cylinder with a diameter of 2.0 inches and a maximum water capacity of 16 cubic inches; and a service pressure of 4500 psig. The cylinder is designed in accordance with the ISO 11119-2 Standard ("Gas cylinders of composite construction - Specification and test methods - Part 2: Fully wrapped fibre reinforced composite gas cylinders with load-sharing metal liners"), except that:

Section 6.1.1 The cylinder liner must be a seamless cylinder made of aluminum alloy 6061 of T-6 temper.

- (i) The liner may be produced by cold or hot backward extrusion; or cold drawing; or from an extruded tube with swaged or spun ends.
- (ii) The material composition of the alloy used must be within the limits prescribed herein:

ELEMENT	ALLOY 6061	
	MIN %	MAX %
Silicon	0.40	0.80
Iron	-	0.70
Copper	0.15	0.40
Manganese	-	0.15
Magnesium	0.80	1.20
Chromium	0.04	0.35
Zinc	-	0.25
Titanium	-	0.15
Lead	-	0.005
Bismuth	-	0.005
Others Each	-	0.05
Others Total	-	0.15
Aluminum	Remainder	

- (iii) The liner interior surface shall be smooth. Any fold in the neck region due to the forming or spinning process must not be sharp or deep or detrimental to the integrity of the cylinder. Inner surface defects may be removed by machining or other method, provided the metal loss is minimal and the minimum required wall thickness is maintained.
- (iv) Liner ends must be concave to pressure.
- (v) Prior to any test, all cylinders must be subjected to a solution heat treatment and aging heat treatment appropriate for aluminum alloy 6061. The process must produce liners of uniform temper and properties.
- (vi) The limits for the mechanical properties of alloy 6061 T6 temper prior to filament winding shall be as follows:

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Yield Strength (Min)	241,316 KPa (35,000 psi)
Tensile Strength (Min)	262,001 kPa (38,000 psi)
Elongation 5.1 cm (2"gage) (Min)	14%
Elongation (24t×6t)	10%

- (vii) The outer surface of each liner must be protected from any galvanic corrosion that may occur due to dissimilar materials (aluminum and carbon fibers) in contact. A suitable polymer coating or glass-fiber/epoxy composite layer may be used for this purpose.
- (viii) Physical tests. To determine yield strength, tensile strength and elongation of the aluminum liner material. Applies to aluminum liner only.
- (1) Required on 2 specimens cut from one liner taken at random out of each lot of 200 liners or less. A "lot" means a group of cylindrical liners successively produced having the same: size and configuration, specified material of construction, process of manufacture and heat treatment process conditions.
 - (2) Specimens must be: Gauge length of 5.1 cm (2 inches) with width not over 3.8 cm (1-1/2 inches); or gauge length of 4 times the specimen diameter (4D bar); a specimen with gauge length at least 24 times the thickness with the width not over 6 times the thickness is also authorized when the liner wall is not over 0.48 cm (3/16 inch) thick. The specimen, exclusive of grip ends, must not be flattened. Grip ends may be flattened to within 2.5 cm (one inch) of each end of the reduced section. When the size of the liner does not permit securing straight specimens, the specimens may be taken in any location or direction and may be straightened or flattened cold and by pressure only, not by blows. When such specimens are used, the inspector's report

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must show that the specimens were so taken and prepared. Heating of specimens for any purpose is not authorized.

- (3) The yield strength in tension shall be the stress corresponding to a permanent strain of 0.2 percent of the gauge length.
 - (a) The yield strength shall be determined by the "offset" method as prescribed by ASTM Standard E8-78.
 - (b) For the purpose of strain measurement, the initial strain shall be set while the specimen is under a stress of 41,369 kPa (6,000 psi), the strain indicator reading being set at the calculated corresponding strain.
 - (c) Cross-head speed of the testing machine shall not exceed 0.32 cm (1/8 inch) per minute during yield strength determination.

Section 6.2.2 The resin system must be tested on a sample coupon representative of the composite overwrap in accordance with ASTM D-2344-89 for water boil shear test. The minimum shear strength may not be less than 34,474 kPa (5000 psi).

Section 7.2.4 c) The working pressure, p_w (if applicable and which shall not exceed test pressure $\times 3/5$)

b. TESTING - The cylinders must be tested in accordance with the ISO 11119-2 prototype design requirements except that:

Section 8.5.3 *Liner burst test* - Not required.

Section 8.5.4 *Cylinder burst test*. The minimum required burst pressure is 3.4 times the marked service pressure marked on the cylinder. A minimum of three cylinders must be hydrostatically tested in accordance with the following:

- (i) Procedure: Pressurize each cylinder at a uniform rate up to 3.4 times the marked service pressure marked on the cylinder, and hold at that pressure for a minimum of 60 seconds. The rate of

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pressurization may not exceed 1,379 kPa (200 psi) per second. Increase the pressure to failure and record the pressure at the onset of failure. Cylinders used in the ambient temperature cycling test may be used for the burst test.

- (ii) Acceptable test results: In no case may the burst pressure of any cylinder be less than the required minimum burst pressure. The failure initiation must be in the cylindrical part of the cylinders.

Section 8.5.5 *Ambient cycle test.* At a minimum, two cylinders must be subjected to cycling pressurization tests in accordance with the following:

- (i) Procedure: Pressurize the cylinder between a pressure not greater than 10 percent of service pressure and the service pressure at a rate not to exceed 10 cycles per minute. The minimum dwell time in the pressure range between 90 and 100 percent of the service pressure may not be less than 1.2 seconds. Each cylinder must be subjected to a minimum of 10,000 cycles. Following the cycling test to service pressure, each cylinder must be subjected to a minimum of 3-0 pressurization cycles by pressurizing between approximately zero and the minimum required test pressure. The dwell time between 90 100 percent of the maximum test pressure may not be less than 1.2 seconds.
- (ii) Acceptable test results: Each test cylinder must withstand the cycling pressurization test without any evidence of visually observable damage, distortion or leakage. After successfully passing the cycling test, the cylinder must be burst tested in accordance with the procedure described in CFFC-10(b)(i) of this standard. The residual burst strength of the cylinder must be at least 90 percent of the required minimum burst pressure (3.06 times service pressure).

Section 8.5.6 *Environmental cycle test.* Two cylinders shall be cycle tested in accordance with the following:

- (i) Procedure: The cycling rate may not exceed 10 cycles per minute. The dwell time between 90 and 100 percent of the maximum test pressure may not be less than 1.2 seconds.

Step 1: Cycle test at ambient temperature by pressurizing from approximately zero pressure to service pressure for 10,000 cycles.

Step 2: Pressurize and maintain the cylinder at service pressure and subject the cylinder to a minimum of 20 thermal cycles at each temperature of 93.3°C (200°F) and minus 51.6°C (minus 60°F) maintaining the dwell time at each extreme temperature to a minimum of 10 minutes.

Step 3: After successfully passing the cycling test, the cylinder shall be burst tested in accordance with the procedure described in CFFC-10(b)(i) of this standard.

- (ii) Acceptable test results: The test cylinder must withstand the thermal cycling test without any evidence of visually observable damage, distortion or leakage. In addition, the residual burst strength of the cylinder must be at least 90 percent of the required minimum burst pressure (3.06 times service pressure).

Section 8.5.11 Salt water immersion test - Not required.

Section 8.5.12 Torque test. The torque test is not required. However:

- (i) Threads must be clean cut, even, without checks, and must be designed in compliance with the requirements of the Federal Standard FED-STD-H28, Appendix A5.
- (ii) Tapered threads are not permitted.

- (iii) Straight threads having at least 6 threads must have a calculated factor of safety in shear of at least 10 at the test pressure for the cylinder. The threads must extend completely through the neck.

Section 8.5.13 High temperature creep test - Not required.

c. BATCH TESTING -

Section 9.1.2 The liner hardness test is not required.

Section 9.1.3 The liner burst test is not required.

d. MARKING - The cylinders must be marked in accordance with 49 CFR § 178.71(o) except that the marking must contain the special permit number "DOT-SP 15415" in lieu of the ISO Standard.

e. REQUALIFICATION - Cylinders must be requalified at least once every three years. Visual inspection must be in accordance with the latest edition of CGA Pamphlet C-6.2 "Guidelines for Visual Inspection and Re-qualification of Fiber Reinforced High Pressure Cylinders", except as specifically noted herein:

- (i) The hydrostatic volumetric expansion test is not required in accordance with 180.209(a), Note 1.

- (ii) Reinspection markings must be applied on a label securely affixed to the cylinder and over-coated with epoxy, near the original test date. Metal stamping of the composite is prohibited. Reheat treatment of rejected cylinders is not authorized.

- (iii) Cylinders with fiber damage (cuts, abrasions, etc.) that exceeds Level 1 type damage as defined in CGA Pamphlet C-6.2 and meet the following depth and length criteria are considered to have Level 2 damage:

- (1) Depth - Damage that upon visual inspection is seen to penetrate the outer fiberglass layer but does not expose the carbon layer beneath, or that has a measured depth of greater than 0.005 inch and less than 0.045 inch for cylinders with

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an outside diameter greater than 7.5 inches or less than 0.035 inch for cylinders 7.5 inches or less in outside diameter;

- (2) Length - Damage that has a maximum allowable length of:

Region	Direction of fiber damage	Maximum length of damage
Cylinder sidewall and domes	Transverse to fiber direction (longitudinal direction)	20% of the straight sidewall section length
Cylinder sidewall and domes	In fiber direction (circumferential direction)	20% of the straight sidewall section length

- (i) Cylinders with damage that meets the Level 2 criteria must be rejected. Retesters must contact the cylinder manufacturer in the event that the damage cannot be clearly interpreted based on these criteria. Repair of rejected cylinders is authorized for Level 2 type damage. Repairs must be made in accordance with CGA Pamphlet C-6.2, prior to the hydrostatic pressure test. Repairs must be evaluated after the hydrostatic test.
- (ii) Cylinders that have direct fiber damage that penetrates through the outer fiberglass layer and into the carbon layer, or that have a measured damage depth of greater than the Level 2 maximum are considered to have Level 3 type damage. Cylinders that have damage with depth meeting Level 2, but length exceeding the Level 2 maximum, are considered to have Level 3 type damage. Cylinders with Level 3 type damage are not authorized to be repaired, and must be condemned.
- (iii) Persons who perform inspection and testing of cylinders subject to this special permit must comply with § 180.205(b) and with all the terms and conditions of this special permit.

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f. OPERATIONAL CONTROLS -

- (i) Cylinders manufactured under this special permit are not authorized for use in underwater applications.
- (ii) Any cylinder exhibiting evidence of fire or excessive heat damage may not be retested under the terms of this special permit.
- (iii) Cylinders manufactured under this special permit are not authorized for use fifteen (15) years after the date of manufacture.
- (iv) Cylinders used in oxygen service must conform to § 173.302(b)(1).
- (v) Transportation of oxygen is only authorized when in accordance with § 173.302 (f).
- (vi) Cylinders must be packaged in accordance with § 173.301(a)(9).

8. SPECIAL PROVISIONS:

- a. In accordance with the provisions of Paragraph (b) of § 173.22a, persons may use the packaging authorized by this special permit for the transportation of the hazardous materials specified in paragraph 6, only in conformance with the terms of this special permit.
- b. A person who is not a holder of this special permit, but receives a packaging covered by this special permit, may reoffer it for transportation provided no modification or change is made to the packaging and it is offered for transportation in conformance with this special permit and the HMR.
- c. A current copy of this special permit must be maintained at each facility where the package is offered or reoffered for transportation.
- d. Each packaging manufactured under the authority of this special permit must be either (1) marked with the name of the manufacturer and location (city and state) of the facility at which it is manufactured or (2) marked with a registration symbol designated by the Office of Hazardous Materials Special Permits and Approvals for a specific manufacturing facility.

- e. A current copy of this special permit must be maintained at each facility where the packaging is manufactured under this special permit. It must be made available to a DOT representative upon request.
9. MODES OF TRANSPORTATION AUTHORIZED: Motor Vehicle, Cargo aircraft, Cargo Vessel, Rail Freight.
10. MODAL REQUIREMENTS: A current copy of this special permit must be carried aboard each cargo vessel, aircraft or motor vehicle used to transport packages covered by this special permit. The shipper must furnish a copy of this special permit to the air carrier before or at the time the shipment is tendered.
11. COMPLIANCE: Failure by a person to comply with any of the following may result in suspension or revocation of this special permit and penalties prescribed by the Federal hazardous materials transportation law, 49 U.S.C. 5101 et seq:
- o All terms and conditions prescribed in this special permit and the Hazardous Materials Regulations, 49 CFR Parts 171-180.
 - o Persons operating under the terms of this special permit must comply with the security plan requirement in Subpart I of Part 172 of the HMR, when applicable.
 - o Registration required by § 107.601 et seq., when applicable.

Each "Hazmat employee", as defined in § 171.8, who performs a function subject to this special permit must receive training on the requirements and conditions of this special permit in addition to the training required by §§ 172.700 through 172.704.

No person may use or apply this special permit, including display of its number, when this special permit has expired or is otherwise no longer in effect.

Under Title VII of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU)—"The Hazardous Materials Safety and Security Reauthorization Act of 2005" (Pub. L. 109-59), 119 Stat. 1144 (August 10, 2005), amended the Federal hazardous

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materials transportation law by changing the term "exemption" to "special permit" and authorizes a special permit to be granted up to two years for new special permits and up to four years for renewals.

12. REPORTING REQUIREMENTS: Shipments or operations conducted under this special permit are subject to the Hazardous Materials Incident Reporting requirements specified in 49 CFR §§ 171.15 Immediate notice of certain hazardous materials incidents, and 171.16 Detailed hazardous materials incident reports. In addition, the grantee(s) of this special permit must notify the Associate Administrator for Hazardous Materials Safety -- OHMSPA, in writing, of any incident involving a package, shipment or operation conducted under terms of this special permit.

Issued in Washington, D.C.:



for Dr. Magdy El-Sibaie
Associate Administrator for Hazardous Materials Safety

Address all inquiries to: Associate Administrator for Hazardous Materials Safety, Pipeline and Hazardous Material Safety Administration, U.S. Department of Transportation, East Building PHH-30, 1200 New Jersey Avenue, Southeast, Washington, D.C. 20590.

Copies of this special permit may be obtained by accessing the Hazardous Materials Safety Homepage at http://hazmat.dot.gov/sp_app/special_permits/spec_perm_index.htm Photo reproductions and legible reductions of this special permit are permitted. Any alteration of this special permit is prohibited.

PO: BMOORE