Transportation of Dangerous Goods Directorate
L'Esplanade Laurier
300 Laurier Avenue West
Ottawa, Ontario
K1A 0N5

Direction générale du transport des marchandises dangereuses
L'Esplanade Laurier
300, avenue Laurier Ouest
Ottawa (Ontario)
K1A 0N5

Equivalency Certificate
(Approval issued by the competent authority of Canada)

Certificate Number: SH 13375 (Ren. 2)

Template Number: N/A

Certificate Holder: Composite Advanced Technologies, LLC

Mode of Transport: Road

Effective Date: March 17, 2023

Expiry Date: May 31, 2025

LEGEND

For the purposes of this equivalency certificate, documents referred to by an abbreviation have the following meaning:

TDG Act: *Transportation of Dangerous Goods Act, 1992*

TDG Regulations: *Transportation of Dangerous Goods Regulations*

CSA B341-18: CSA Standard B341-18, "*UN pressure receptacles and multiple-element gas containers for the transport of dangerous goods*", June 2018, published by the Canadian Standards Association (CSA)

CSA B342-18: CSA Standard B342-18, "*Selection and use of UN pressure receptacles, multiple-element gas containers, and other pressure receptacles for the transport of dangerous goods, Class 2*", June 2018, published by the Canadian Standards Association (CSA)

ISO 11515:2013: International Standard ISO 11515:2013, "*Gas cylinders – Refillable composite reinforced tubes of water capacity between 450 L and 3000 L – Design, construction and testing*", published by the International Organization for Standardization

NOTES

Note 1: Subsection 31(4) of the *TDG Act* stipulates that any non-compliance with the conditions of this equivalency certificate will result in the provisions of the *TDG Act* and *TDG Regulations* to apply as though this equivalency certificate did not exist.

Note 2: This equivalency certificate provides no regulatory relief other than specifically stated herein. Therefore, all other requirements of the *TDG Act* and the *TDG Regulations* apply.

PURPOSE

(The following is for information purposes only and is not part of the certificate.)

This equivalency certificate authorizes the handling, offering for transport and transporting of tubes in a manner that does not comply with Part 5 of the *TDG Regulations*. The tubes are interconnected by a manifold and assembled within a framework. Such an assembly of tubes is typically known as a multiple-element gas container. The certificate holder has demonstrated that when used and tested under the stipulated conditions of this equivalency certificate, the tubes could be used with an equivalent level of safety. The basis for seeking relief is demonstration of equivalent level of safety as TC specification cylinders by designing and testing per *ISO 11515:2013* with certain exceptions.

CONDITIONS

This equivalency certificate authorizes:

- **Composite Advanced Technologies, LLC** to design, manufacture, sell, offer for sale, deliver, or distribute in Canada, means of containment used or intended to be used in importing, handling, offering for transport, or transporting dangerous goods in a manner that does not comply with section 5.1 and section 8 of the *TDG Act, 1992*,

- **any person** to sell, offer for sale, deliver, distribute, import, or use a standardized means of containment in a manner that does not comply with section 8 of the *TDG Act, 1992*, and

- **any person** to handle, offer for transport, transport, or import, by road vehicle, dangerous goods included in Class 2 in a means of containment in a manner that does not comply with sections 5(a) in relation to safety requirements only, (c), and (d) of the *TDG Act, 1992*, and paragraphs 1.7(a) and (c), sections 5.1.1 and 5.2, and subparagraph 5.10(1)(a)(iii) of the *TDG Regulations*, in relation to the manufacture, selection, and use of means of containment only,

if the following conditions are met:

A) SELECTION AND USE

1) Subject to conditions A)2) to A)25) of this equivalency certificate, the requirements with respect to composite UN tubes and multiple-element gas containers set out in *CSA B342-18* are complied with;

2) Subject to condition A)4) of this equivalency certificate, each means of containment is a multiple-element gas container (i.e. an assembly of tubes interconnected by a manifold and assembled within a framework) that meets the definition of “container” within the terms of the International Maritime Organization’s (IMO) “*International Convention for Safe Containers, 1972*”, 2014 edition, cited in the rest of this certificate as the International Convention for Safe Containers, 1972;

3) The container assembly complies with **Composite Advanced Technologies, LLC**’s drawing no. CAT-MT-1, filed by the certificate holder with the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada;

4) Each container is in conformity with the *International Convention for Safe Containers, 1972*, and a Safety Approval Plate conforming to the specifications set out in the Appendix to Annex I of the *International Convention for Safe Containers, 1972* is permanently affixed to the container at a readily visible place. The structural framework has been evaluated for transportation of the tubes under this equivalency certificate by Finite Element Analysis (FEA) on file with the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada. This FEA demonstrated the framework's ability to protect the tubes from damage due to front, rear, or side impact, and overturning. The Frame design meets the requirements of *CGA C-29-2019*, "*Standard for Design Requirements for Tube Trailers and Tube Modules*";

5) The tubes are used only for:

UN Number	Shipping Name and Description	Class	Packing Group
UN1006	ARGON, COMPRESSED	2.2	N/A
UN1046	HELIUM, COMPRESSED	2.2	N/A
UN1049	HYDROGEN, COMPRESSED	2.1	N/A
UN1065	NEON, COMPRESSED	2.2	N/A
UN1066	NITROGEN, COMPRESSED	2.2	N/A
UN1954	COMPRESSED GAS, FLAMMABLE, N.O.S.	2.1	N/A
UN1971	METHANE, COMPRESSED; or NATURAL GAS, COMPRESSED with high methane content	2.1	N/A

6) When used in natural gas service, methanol or glycol is not deliberately added to the natural gas and the composition of the natural gas meets one of the following conditions:

   a) for dry gas, the maximum gas contaminant limits apply:

      i) 32 mg/m^3 of water vapour,

      ii) 23 mg/m^3 of hydrogen sulphide, and

      iii) 1 % by volume of oxygen, or

b) for wet gas, the maximum gas contaminant limits apply:

i) 23 mg/m3 of hydrogen sulphide and other soluble sulphides,

ii) 115 mg/m3 total sulphur,

iii) 1 % by volume of oxygen,

iv) 3 % by volume of carbon dioxide, and

v) 0.1 % by volume of hydrogen;

7) The dangerous goods are compatible with the materials of containment under the conditions of use;

8) Each tube is fitted with a shut-off valve that is closed during transport;

9) The manifold valves are closed during transport;

10) The manifold is depressurized before transport;

11) A minimum pressure of 1.7 MPa (250 psig) is maintained in each tube while in service and during unloading operations in accordance with **Composite Advanced Technologies, LLC** Operational Manual, filed by the certificate holder with the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada;

12) Subject to condition A)13) of this equivalency certificate, top of the framework is covered by galvanized, corrugated aluminum panels and the plumbing components and bottom are covered by flat aluminum sheet metal;

13) The covered area surrounding the tubes and the enclosed area where manifold, piping, and valves are located are vented to the outside;

14) Despite clause 4.6 of *CSA B342-18*, each tube is individually equipped with a fire protection system consisting a shape memory alloy wire linkage that is encapsulated in stainless steel tubing. During a fire scenario, the linkage acts as a trigger for the tank assembly's Pressure Relief Device (PRD) and, through mechanical action, activates the PRD to vent the hazardous lading from the system. The fire protection system vent lines direct the released gas upwards and outside of the frame system, unobstructed, to the open air in such a manner as to prevent any impingement of escaping gas upon the tubes and shall be located such that they will not be blocked in the event of a rollover of the container. No additional PRD (e.g., rupture disks) are authorized on the tubes. The pressure relief lines shall be protected from intrusion of water and debris by a spring-loaded rain cap which does not restrict flow from relieving devices. The fire protection system is capable of preventing the rupture of normally filled tubes when subjected to a fire resistance test conducted in accordance with clause 8.5.9 of *ISO 11515:2013*;

15) The requirements in clauses 5.1.3 and 5.1.4 of *CSA B342-18* do not apply;

16) The tubes are not filled:

a) if they are due for periodic inspection and testing,

b) unless they and their structural and service equipment have been examined and found to be in good working order,

c) unless they and their pressure-relief devices, valves, and other accessories are suitable for the intended product and pressure,

d) if they are damaged to such an extent that their integrity or structural or service equipment could be affected. The tubes are evaluated for damage at time of filling in accordance with **Composite Advanced Technologies, LLC**'s CT-590He Type IV Cylinder and Trailer Operator's Manual filed by the certificate holder with the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada,

e) if they were exposed to ambient temperatures below -12°C with less than 0.7 MPa of internal pressure, prior to sale, unless they have been:

i) conditioned at a temperature above 16°C for at least 8 hours, or

ii) conditioned in accordance with the cold fill procedure specified in the **Composite Advanced Technologies, LLC**'s Operational Manual filed by the certificate holder with the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada, and

f) unless the required markings specified in conditions B)34) and B)37) of this equivalency certificate are legible;

17) The tubes are operated and maintained in accordance with **Composite Advanced Technologies, LLC**'s "CT-590He Type IV Cylinder and Trailer Operator's Manual";

18) Before transport, the fire protection system is inspected for leaks and the vent tubes are inspected for collection of moisture, dust, or debris that could plug the vents in accordance with **Composite Advanced Technologies, LLC**'s WI.PANEL.TEST filed by the certificate holder with the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada;

19) The frame assembly and chassis has a minimum rigid body Static Rollover Threshold of 0.44;

20) Each container is pulled by a vehicle that is equipped with an electronic stability control (ESC) system in accordance with the appropriate Federal Motor Vehicle Safety Standard (FMVSS). If an ESC-equipped vehicle is not used, the trailer shall be equipped with air-brakes and an anti-lock braking (ABS) system, in accordance with FMVSS 393.55 and that contains an electrical circuit to signal a malfunction in the trailer's ABS system;

21) The filling infrastructure has controls to prevent overpressurizing during filling;

22) Tubes that have been subjected to fire are not returned to service;

23) Means of containment that have been involved in a vehicle collision are removed from service until they, their service and structural equipment, and the tubes comprising the means of containment have been inspected for damage and determined to be in good working order by the equivalency certificate holder;

24) The tubes are not used for underwater applications;

25) Not more than 15 years has elapsed since the original manufacturing test date for each tube.

B) MANUFACTURE AND PERIODIC INSPECTION AND TESTING

1) Subject to conditions B)2) to B)34) of this equivalency certificate, each tube was designed, constructed, and initially inspected and tested in accordance with the requirements applicable to fully-wrapped composite tubes with non-load-sharing non-metallic liners specified in *ISO 11515:2013*;

2) Each tube was manufactured by **Composite Advanced Technologies, LLC**, 7441 East Orem Drive, Houston, TX, 77075, USA, in accordance with the quality control system manual, the specific procedures, the manufacturing and material specifications, the design qualification test reports, and drawing no. CAT1502-L, parts no CAT1502-L-01 and CAT1502-L-02, dated 8/10/2016 for the liner, drawing no. CAT 1502-202-04 dated 8/8/2016 for the polar boss, and drawing no. CAT1502-105, parts no. CAT1502-01 and CAT1502-02, dated 8/10/2016 for the finished tube, filed by the certificate holder, with the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada;

3) Despite Clause 3.5 of *ISO 11515:2013*, a batch of non-metallic liners is the quantity of liners of the same nominal diameter, length, thickness and design, made from the same materials and subjected to the same manufacturing process;

4) Despite Clause 3.7 of *ISO 11515:2013*, a batch of finished tubes is a production quantity of up to 200 finished tubes serially produced (plus finished tubes required for destructive testing) or 12 months of production, whichever occurs first, of the same nominal diameter, length, thickness, wrapping pattern, and design;

5) Each tube consists of a HDPE (High Density Poly Ethylene) liner wrapped with resin-impregnated carbon fiber filament windings in both longitudinal and circumferential directions. A stainless steel end boss is integrally molded into the pole of each end of the liner to provide interface for connecting the tube to the gas system and for mounting to the framework;

6) The plastic liner is made from a HPDE copolymer using a roto-molding process. The wall thickness of each liner shall meet the minimum specified dimension and the material specification shall be certified by the supplier. Both shall be specified in the design qualification test reports filed by the certificate holder, with the Executive Director, Regulatory Frameworks and International Engagement, Transportation of Dangerous Goods Directorate, Transport Canada;

7) The yield strength and the ultimate elongation for the qualification of the plastic liner material are determined at 23°C in accordance with International Standard ISO 527-2: 2012, "*Plastics – Determination of tensile properties – Part 2: Test conditions for moulding and extrusion plastics*", February 2012, published by the International Organization for Standardization (ISO), and at -40°C in accordance with ASTM D- 638-02, "Standard Test Method for Tensile Properties of Plastics". The minimum yield strength is 16 MPa and the minimum ultimate elongation is 10%. A material certificate of conformance from the plastic manufacturer is deemed acceptable;

8) The softening temperature for the qualification of the plastic liner material is determined in accordance with International Standard ISO 306:2013, "*Plastics – Thermoplastic materials – Determination of Vicat softening temperature (VST)*", November 2013, published by the *International Organization for Standardization* (ISO), and is at least 100°C. A material certificate of conformance from the plastic manufacturer is deemed acceptable;

9) The melt index and density of the HDPE liner material is checked in accordance with **Composite Advanced Technologies, LLC**'s Quality Assurance Intake form QA-IF-LINER Rev. 5 and meets the material specification;

10) The carbon fiber material is tested for tow strength, tow modulus, density, size content and tow elongation in accordance with **Composite Advanced Technologies, LLC**'s Quality Assurance Intake Inspection Form, QA-IF-CARBONFIBER Rev 3 and meets the specified mechanical property requirements **in Composite Advanced Technologies, LLC**'s material specification form number SPEC-MIT-001, dated August 10, 2016;

11) Resin materials are qualified on a sample coupon representative of the composite overwrap in accordance with International Standard ISO 14130:1997*, "Fibre-reinforced plastic composites – Determination of apparent interlaminar shear strength by short-beam method*", December 1997, published by the International Organization for Standardization (ISO), or ASTM D2344, "*Standard Test Method for Short-Beam Strength of Polymer Matrix Composite Materials and Their Laminates*". The test shall be performed following the boiling of the test sample in water for 24 hours. The composite shall have a minimum shear strength of 13.8 MPa;

12) The viscosity, weight per epoxide, and colour of the resin materials are tested in accordance with **Composite Advanced Technologies, LLC**'s Quality Assurance Intake Inspection Form, CAT-IF-RESIN, Rev. 1 and meet the material specifications;

13) The hardener material is tested for appearance, viscosity, anhydride molecular weight and gel time in accordance with **Composite Advanced Technologies, LLC**'s Quality Assurance Intake Inspection Form, QA-IF-HARDENER, Rev. 1;

14) The characteristics of the Polar Boss specifications are indicated on **Composite Advanced Technologies, LLC**'s Quality Assurance Intake Inspection Form, QA-IF-POLARBOSS, Rev. 2 and are inspected for the following qualities: yield and tensile strength and elongation, heat treatment and dimensions;

15) The tensile and yield strength and elongation are tested for qualification of the polar boss material in accordance with ASTM A 370-17 and meet the requirements of form SPEC-BOSS-005, dated August 10, 2016;

16) The characteristics of the Fixed Ends specifications are indicated on **Composite Advanced Technologies, LLC**'s Quality Assurance Intake Inspection Form, CAT-IF-FIXED END INSERTS, and are inspected for the following qualities: yield and tensile strength and elongation, material analysis, heat treatment and dimensions;

17) The characteristics of the Floating Ends specifications are indicated on **Composite Advanced Technologies, LLC**'s Quality Assurance Intake Inspection Form, CAT-IF-FLOATING END INSERTS, and are inspected for the following qualities: yield and tensile strength and elongation, material analysis, heat treatment and dimensions;

18) Inspections, tests, and verifications are in accordance with the requirements of *ISO 11515:2013* and carried out by an inspection body registered with Transport Canada in accordance with Annex A of *CSA B341-18*. In addition, the inspection body:

    a) performs, verifies, or witnesses the additional design qualification tests specified in this equivalency certificate,

    b) for each new tube design, prepares a report that includes, as a minimum, all information shown in Annex A of *ISO 11515:2013*, and

    c) for each tube batch, prepares a report that includes, as a minimum, all relevant information shown in Annex B of *ISO 11515:2013*. This excludes liner hardness check and filament strand strength verification, replaces "mechanical tests on liners" data categories with melt index and density, replaces "***Hydraulic volumetric expansion test certificate...***" with **"Hydraulic proof test certificate..."**, eliminates customer order number field, and specifies fields for tube serial number, test date, test pressure, hold time, and pass/fail status. The reports are retained by the manufacturer and by the inspection body for the service life of the tubes;

19) Unless otherwise specified in this equivalency certificate, the prototype tubes may be full-scale tubes representative of the new design or a shorter tube with the same nominal diameter, and manufactured using the same materials and manufacturing technique, and using a representative wrapping pattern (same number of strands and same number of layers) so as to represent an equivalent stress compared to a full scale prototype. The length-to-diameter ratio shall not be less than 2.5;

20) Despite Table 4 referenced in Clauses 8.2.5 and 8.4.4 of *ISO 11515:2013*, Table 1 of Appendix B of this equivalency certificate is used for determining the level of reduced testing for design variants;

21) The hydraulic proof pressure test is performed in accordance with Clause 8.5.1 of *ISO 11515:2013*, and the weight of the water is recorded at ambient temperature and pressure and at test pressure. The difference is recorded as the expansion;

22) The tube burst test is performed in accordance with Clause 8.5.4 of *ISO 11515:2013*, except that the burst pressure or pressure at failure must be not less than 1.6 times the test pressure of the composite tube design. These tubes shall be full-scale prototypes representative of the new design;

23) The ambient cycle test is performed on two tubes in accordance with Clause 8.5.5 of *ISO 11515:2013*, except that the tubes must be cycled to 130% of the working pressure or higher, representing the maximum developed pressure at 65^{o}C. One tube shall be a full-scale prototype representative of the new design;

24) The environmental cycle test is performed in accordance with Clause 8.5.6 of *ISO 11515:2013*, except that the tube shall be conditioned at a pressure no greater than 10% of the working pressure and pressure-cycled from a pressure no greater than 10% of the working pressure. The burst pressure must not be less than 1.4 times the test pressure;

25) The fire resistance test is performed in accordance with Clause 8.5.9 of *ISO 11515:2013*. The tube shall be a full-scale prototype representative of the new design;

26) As an alternative to the leak test specified in Clause 8.5.11 of *ISO 11515:2013*, the leak test is performed as follows:

    a) the tubes are thoroughly dried;

    b) the tubes are pressurized to working pressure using a suitable fluid,

    c) the tubes are held at working pressure for at least 15 minutes and examined for signs of leakage (for example, a visual indication or decrease in pressure), and

    d) tubes showing evidence of leakage are rejected;

27) Instead of the gas cycle test specified in Clause 8.5.14 of *ISO 11515:2013*, a finished prototype tube is subjected to a gas cycling and blowdown test in accordance with section 1 of Appendix A of this certificate;

28) The vacuum test specified in Clause 8.5.18 of *ISO 11515:2013* is not required. A warning regarding not using under vacuum shall be permanently marked on the tube label in accordance with condition B)34) of this equivalency certificate;

29) A finished prototype tube is subjected to the high velocity impact (gunfire) test in accordance with Clause 8.5.10 of *ISO 11119-3:2013*, except that the tube shall be impacted by a 12.7 mm armour-piercing projectile. Additional rounds may be used to impact the same location as the prior round until penetration is achieved;

30) Despite Clause 9.5.6 of *ISO 11515:2013*, an ambient cycle test is performed on one finished tube from each production quantity of up to 5 batches or one year of tube production, whichever occurs first, in accordance with condition B)23) of this equivalency certificate. The ambient cycle test may be conducted on the first tube of the batch;

31) Despite Clause 9.5.7 of *ISO 11515:2013*, a burst test is performed on one finished tube from each production quantity of up to 5 batches or one year of tube production, whichever occurs first, in accordance with condition B)22) of this equivalency certificate. The burst test may be conducted on the first tube of the batch. The tube subjected to the ambient cycle test in accordance with condition B)23) of this equivalency certificate may be used for this test;

32) Any tube that is dropped from a height greater than 0.6 m during the manufacturing process or prior to assembly within the framework is condemned;

33) Clause 10 of *ISO 11515:2013* does not apply;

34) Each tube is permanently marked in accordance with Clause 4.4 of *CSA B341-18* except that:

    a) the mark required by Clause 4.4.1.2.1(a) of *CSA B341-18* is not applied,

    b) the mark required by Clause 4.4.1.2.1(b) of *CSA B341-18* is replaced with "**TC-SH 13375**",

    c) the text "**WARNING – THIS TUBE MUST NOT BE USED IN VACUUM SERVICE" or "WARNING – 17 BAR (250 PSIG) MUST BE MAINTAINED IN TUBE WHILE IN SERVICE AND DURING UNLOADING OPERATIONS**", is permanently and legibly marked,

    d) the size of the marks must be not less than 12 mm in height;

35) Subject to conditions B)36) and B)37) of this equivalency certificate, the container is in conformity with the requirements of Clause 5 of *CSA B341-18*:

36) The requirement in Clause 5.1.3 of *CSA B341-18* does not apply;

37) The container is fitted with a corrosion-resistant metal identification plate permanently attached in a conspicuous place and readily accessible for inspection in accordance with Clause 5.7 of *CSA B341-18*, except that the mark required by Clause 5.7.2(c)(i) is replaced with **"TC-SH 13375"**;

38) Subject to condition B)39) of this equivalency certificate, the requirements in Clause C.2.6 (b) and Clause C.2.6(c) of *CSA B341-18* do not apply;

39) The container is tested in accordance with the test plan filed by the certificate holder, with the Executive Director, Regulatory Frameworks and International Engagement, Transportation of Dangerous Goods Directorate, Transport Canada;

40) Each tube is subjected to periodic inspection and testing at least every five years in accordance with the requirements applicable to UN composite tubes in *CSA B341-18*, except that:

    a) the test pressure (1.5 times the marked working pressure) is held for at least 3 minutes without loss of pressure,

    b) the periodic inspection and test report is kept for the service life of the tube. The report shall include, as a minimum, the inspection results for each type of damage described in CGA C-6.2, "*Standard for Visual Inspection and Requalification of Fiber Reinforced High Pressure Cylinders*". The owner of the tube and the person who prepared the report shall each keep a copy of the report for the service life of the tube;

41) Each container is inspected at least every five years in accordance with Clause 19.2 of *CSA B341-18*, or another method approved by the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada;

42) The certificate holder, tube owner, or user must report, in writing, any incident related to a package, shipment or operation conducted under the terms of this certificate involving loss of contents or failure of the tubes to the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada;

43) Before the expiry date of this equivalency certificate, the certificate holder reports a summary of the tube manufacturing and performance experience to the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada;

44) Each side of the means of containment as well as the rear cabinet of the means of containment are marked with the letters and numbers **"TC-SH 13375"** that are of a colour contrasting with the background and not less than 50 mm in height;

45) The framework of the means of containment is marked with the words **"No Lifting"** and **"No Stacking"** with characters of not less than 20 mm in height;

46) A person who is not a holder of this equivalency certificate, but receives a packaging covered by this certificate, 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 certificate;

47) A current copy of this equivalency certificate must be maintained at each facility where the package is offered or reoffered for transportation; and

48) This equivalency certificate serves as the registration of **Composite Advanced Technologies, LLC** pursuant to Annex A of *CSA B341-18* to manufacture tubes of the designs specified herein. **Composite Advanced Technologies, LLC**'s registered mark, pursuant to *CSA B341-18*, is:

M6477

Signature of Issuing Authority

David Lamarche, P. Eng., ing.
Manager, Approvals and Special Regulatory Projects

(The following is for information purposes only and is not part of the certificate.)

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Appendix A

Prototype Tests

1. Gas Cycling And Blow Down Test

1.1. Procedure

One finished tube shall be cycle-tested as follows:

a) a shorter tube may be used as an alternative to a full-scale tube. The shorter tube shall be manufactured with the same process, materials, wrapping pattern, shall have the same nominal outside diameter as the full-scale production tube, and shall have a length-to-diameter ratio not less than 2.5,

b) the tube shall be filled with a non-corrosive fluid such as oil, inhibited water or glycol,

c) the pressure in the tube shall be cycled for 1000 cycles, between 10% of service pressure and service pressure. Pressurization shall be performed at a maximum rate of 10 cycles per minute,

d) the pressure shall be released, the fluid shall be drained, and the interior of the tube shall be dried,

e) the pressure in the tube shall be cycled for 5 cycles, between 10% of working pressure and service pressure, with air, nitrogen, or the intended lading. During each cycle, the pressure shall be held at the upper cyclic pressure for at least 2 hours,

f) following the high pressure hold of the final cycle, the gas shall be released freely to the atmosphere, and

1.2. Acceptable results

Following the above test sequence, the cylinder must be subjected to a leak test in accordance with condition B)26) of this equivalency certificate, then the liner and liner/end boss interface shall undergo a visual inspection for evidence of any deterioration, such as fatigue cracking or electrostatic discharge (tube need not be sectioned). The cylinder must have no signs of leakage or deterioration.

Appendix B

Table 1: Design Qualification Tests

	Design Variant Changes														
	New Design	Length <= 50%	Length >50%	Diameter <=20%	Diameter >20% <=50%	Liner thickness >20% or manufacture	Liner material	Equivalent fiber	Test Pressure <=20%	Test pressure >20% <=60%	Composite thickness or pattern	Boss-to-liner interface	Equivalent resin matrix	Resin Matrix	Pressure-Relief Device
Liner material tests							X								
Composite material tests								X			X		X	X	
Hydraulic pressure test	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Hydraulic burst	X	X[1]	X[1]	X[1]	X	X[1]	X[1]	X	X[1]	X	X	X[1]	X[1]	X[1]	
Ambient cycle	X			X[1]	X		X	X[1]	X[1]	X	X	X[1]			
Environmental cycle	X													X	
Flaw tolerance[5]	X				X									X	
Blunt Impact	X				X[4]					X				X	
High velocity impact (gunfire)	X				X[4]					X				X	
Fire resistance	X		X[3]		X[3]					X					X
Permeability	X				X	X	X			X					
Neck strength test	X						X					X		X	
Leak	X				X		X		X	X		X			
Gas cycling and Blow down	X				X	X	X					X[6]			

Notes

1. A minimum of one tube may be used for each design change.
2. Where the design variant's burst pressure to test pressure ratio is over 20% greater than the same ratio for the approved design.
3. Fire resistance test may be omitted if the water capacity stays the same or decreases and the same TRD system is used.
4. Test to be conducted for reduction in diameter only.
5. Only the pressure cycling part of the test is required (not the burst test).
6. For a change of boss-liner interface column, a leak check of the liner interface would be accepted. The gas cycling and blow down test is not required if the boss-liner interface does not change.