



Transportation of Dangerous Goods Directorate
Tower C, Place de Ville
330 Sparks Street
Ottawa, Ontario
K1A 0N5

Direction générale du transport des marchandises dangereuses
Tour C, Place de Ville
330, rue Sparks
Ottawa (Ontario)
K1A 0N5



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

Certificate Number: SH 13911
Certificate Holder: Hexagon Digital Wave, LLC
Mode of Transport: Road
Effective Date: April 12, 2023
Expiry Date: April 30, 2028

LEGEND

For the purposes of this equivalency certificate, the document name listed in the short form has the same meaning as the document name listed in the long form. If a document is referred to in this equivalency certificate, it is referred to by the short form.

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

TDG Regulations: *Transportation of Dangerous Goods Regulations*

CSA B341: CSA Standard B341, “UN pressure receptacles and multiple-element gas containers for the transport of dangerous goods”, published by the Canadian Standards Association (CSA), as amended from time to time

CAN/CGSB-48.9712-2014 / (ISO 9712:2012, IDT): CAN/CGSB-48.9712-2014 / (ISO 9712:2012, IDT), “Non-destructive Testing – Qualification and Certification of Personnel”, dated 2014

ANSI/ASNT CP-189-2011: ANSI/ASNT CP-189-2011, “ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel”, dated 2011

SNT-TC-1A-2016: SNT-TC-1A-2016, “Recommended Practice No. SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing”, dated 2016

Equivalency Certificate SH 13911
(Approval issued by the competent authority of Canada)

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.)

The equivalency certificate holder has demonstrated that certain tubes requalified by the modal acoustic emission test method described in Appendix A to this equivalency certificate could be used with a level of safety at least equivalent to those requalified by methods (hydrostatic testing and internal visual inspection) required by the *TDG Regulations*.

CONDITIONS

This equivalency certificate authorizes **Hexagon Digital Wave, LLC** to display the marks prescribed in respect of tube requalification in a manner that does not comply with:

- section 6 of the *TDG Act*, and

authorizes **any person** to handle, offer for transport, or transport, by road vehicle, tubes in a manner that does not comply with the following requirements:

- subsection 5.1.1(2) of the *TDG Regulations*,
- section 5.2 of the *TDG Regulations*,
- subparagraph 5.10(1)(a)(iii) of the *TDG Regulations*,

if the following conditions are met:

- a) Each tube requalification is performed by **Hexagon Digital Wave, LLC**, hereinafter referred to as the equivalency certificate holder, and is performed in accordance with the documentation filed by the equivalency certificate holder with the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada and in accordance with Appendix A to this equivalency certificate;
- b) Each tube has been manufactured by **Quantum Fuel Systems LLC**, in accordance with the requirements of equivalency certificate SU 11921;
- c) The requalification period for each tube requalified in accordance with this equivalency certificate is five years;
- d) Tubes with evidence of having been subjected to the action of fire are not requalified under this equivalency certificate; and
- e) The equivalency certificate holder reports to the Executive Director, Regulatory Frameworks and International Engagement, Regulatory Affairs Branch, Transportation of Dangerous Goods Directorate, Transport Canada:
 - (i) the name and qualifications of each Senior Review Technologist (SRT), qualified tester, and qualified operator, as defined in Appendix A to this equivalency certificate,
 - (ii) once per 12 calendar months, the number of tubes examined, the specification designation, or the equivalency certificate, permit for equivalent level of safety, or special permit under which each tube was manufactured, their serial numbers and respective owners, and the requalification results including the type and size of the defect(s) of each rejected or condemned tube.

Equivalency Certificate SH 13911
(Approval issued by the competent authority of Canada)

- f) This equivalency certificate serves as the registration of **Hexagon Digital Wave, LLC**, in accordance with Annex B of *CSA B341*, to requalify tubes as specified herein. **Hexagon Digital Wave, LLC**'s registered mark is:

“628”

Signature of Issuing Authority

David Lamarche, P. Eng., ing.

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

Equivalency Certificate SH 13911
(Approval issued by the competent authority of Canada)

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

Contact Person:	Brian Burks Hexagon Digital Wave, LLC 13760 E Arapahoe Road Centennial, Colorado 80112 United States of America
Telephone:	303-790-7559, ext. 12
E-mail:	brian.burks@hexagondigitalwave.com

Legend for Certificate Number

SH - Road, SR - Rail, SA - Air, SM - Marine
SU - More than one Mode of Transport
Ren - Renewal

For more information:

Approvals and Special Regulatory Projects
Transportation of Dangerous Goods,
Transport Canada
300 Laurier Avenue West
Ottawa, Ontario K1A 0N5
E-mail: tdgpermits-permistmd@tc.gc.ca

TDG regional offices:

Atlantic

TDG-TMDAtlantic@tc.gc.ca

Quebec

TMD-TDG.Quebec@tc.gc.ca

Ontario

TDG-TMDOntario@tc.gc.ca

Prairie & Northern

TDG-TMDPNR@tc.gc.ca

Pacific

TDGPacific-TMDPacifique@tc.gc.ca

APPENDIX A

1. REQUALIFICATION METHOD

Each tube shall be visually inspected externally and be subjected to modal acoustic emission (MAE) examination in accordance with the following.

2. VISUAL INSPECTION

Prior to MAE examination, the tube shall be inspected in accordance with Clause 19.2 of CSA *B341* and with “Quantum Fuel Systems LLC TR-17-0012 Rev B” procedure on file with Transport Canada.

3. MODAL ACOUSTIC EMISSION TEST

3.1 Scope of Examination

The entire tube under test shall be tested using equipment, procedures and rejection criteria in accordance with the United States Department of Transportation (U.S. DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) technical report “Modal acoustic emission (MAE) Examination Specification for Requalification of Composite Overwrapped Pressure Vessels (Cylinders and tubes)”, dated May 3, 2018, and supporting documents on file with Transportation of Dangerous Goods Directorate.

3.2 Equipment Calibration

Sensors and recording equipment shall be calibrated annually.

3.3 Sensors

Sensors shall be HDW model B1010 DIP transducers and pulsing sensor HDW model B1025, as described in the Hexagon Digital Wave LLC document “04112022_QT_TrailerTesting” on file with Transport Canada.

3.4 Sensor positioning

Sensors shall be configured and housed within airbags that are inserted between the tubes and inflated in accordance with Quantum VP trailer (SP16524) test procedure, on file with the Transportation of Dangerous Goods Directorate. Once the airbags are properly installed, the sensor placement on each container shall match Figure 2 of the Quantum VP trailer (SP16524) test procedure.

3.5 Sensor coupling

Transducers shall be coupled acoustically to the tube using a viscous or solid couplant and held in place by suitable holders.

3.6 Sensor Verification

The system shall be calibrated and checked using a signal generated by a pencil lead break (PLB) an Auto-Sensor Test (AST), or spring loaded center punch (SLCP). For the coupling check, the extensional and flexural waveforms shall be observed. When done by breaking a pencil lead, a Pentel 2H, 0.5 mm diameter, 3 mm long lead shall be used. The sensitivity of each channel shall be checked by generating a calibration signal in proximity to each sensor. Each transducer array shall measure wave energy of a minimum of 5×10^{-15} Joules and all received waveform energies shall have the same values within a factor of four (4). If this energy level and comparison is not met, the transducer array shall be recoupled or replaced. The threshold for each channel shall be a minimum sensitivity of 50 dB referred to 1 microvolt at the preamplifier input. All coupling check waveforms shall be recorded. The gain settings for the sensor coupling check shall be such that the signal does not saturate either the amplifiers or the A/D converter. If so, the lead breaks shall be repeated at a system gain that does not saturate the system. Prior to pressurization, the gain and threshold shall be reset to the test gain.

3.7 Pressurization

A method shall be provided to continuously read the tube pressure. Pressure shall be applied monotonically from zero to 105% of maximum developed pressure at 65° C. The pressurization rate shall be slow enough so as to not cause flow noise to be detected. Acoustic emissions shall be monitored during the entire pressurization and depressurization process by observing the displays of event waveforms. Acoustic emissions shall be recorded starting when tube pressure reaches 25 MPa (250 bar), and continuing until pressurization is complete. Test pressure shall be held for fifteen minutes or five continuous minutes without an event detected, whichever shall occur first. The pressure during the test shall not drop below the minimum test pressure during this hold time and the actual test pressure shall be stable by the end of the hold time. AE waveforms shall be continuously monitored and recorded during this time. Any significant oscillations or fiber tow fracture shall be cause to terminate the test immediately and safely vent pressure.

3.8 Interpretation of results

Tubes that meet the rejection criteria defined in the United States Department of Transportation (U.S. DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) technical report Modal acoustic emission (MAE) Examination Specification for Requalification of Composite Overwrapped Pressure Vessels (Cylinders and tubes), dated May 3, 2018, and supporting documents on file with Transportation of Dangerous Goods Directorate, shall be rejected and removed from service.

After the tube is depressurized, a sensor verification shall be performed in accordance with 3.6 of Annex A of this equivalency certificate.

4. MODAL ACOUSTIC EMISSION EXAMINATION PERSONNEL

- 4.1 Each person who performs testing or who evaluates or certifies results shall meet the requirements in this equivalency certificate.
- 4.2 A Project Manager is a senior manager of Hexagon Digital Wave LLC responsible for compliance with *TDG Regulations* including this equivalency certificate. Additionally, the Project Manager shall ensure that each operator and Senior Review Technologist (SRT) maintain the required certifications described herein.
- 4.3 The personnel responsible for performing modal acoustic emission testing in accordance with this equivalency certificate shall be qualified to an appropriate level (Level I, Level II or Level III) in modal acoustic emission (MAE) testing in accordance with the *CAN/CGSB-48.9712-2014 / (ISO 9712:2012, IDT)*, *ANSI/ASNT CP-189-2011*, or *SNT-TC-1A-2016* depending on the assigned responsibility as described below:
- a) System start up, system calibration, review, and certification of the test results shall be performed by a SRT or by a qualified tester when written acceptance and rejection criteria has been provided by a SRT. Based upon the written criteria, the qualified tester may authorize tubes that pass the examination to be marked in accordance with section 6 of Appendix A of this certificate;
 - b) A person with Level I certification may perform system start up, check calibration and perform MAE under the direct guidance and supervision of a SRT or a qualified tester, either of whom shall be physically present at the test site to be able to observe examinations conducted under this equivalency certificate.
- 4.4 A SRT shall be a person who provides written MAE procedure, supervisory training, examinations (Level I and II), and technical guidance to operators, reviews and verifies the examination results. An SRT shall have a thorough understanding of the *TDG Regulations* pertaining to the manufacture and requalification of tubes that are authorized under this certificate and shall possess:
- a) a Level III certification in accordance with *CAN/CGSB-48.9712-2014 / (ISO 9712:2012, IDT)*, *ANSI/ASNT CP-189-2011*, or *SNT-TC-1A-2016* in modal acoustic emission examination;
 - b) a Professional Engineer (PE) License with a documented experience for a minimum of 2 years in Non-Destructive Evaluation (NDE) of pressure vessels or pipelines using the modal acoustic examination technique; or
 - c) a PhD degree in a discipline of engineering or physics with documented evidence of experience in non-destructive examination (NDE) of pressure

Equivalency Certificate SH 13911
(Approval issued by the competent authority of Canada)

vessels or pipelines using the modal acoustic examination technique or research/thesis work and authoring/co-authoring of technical papers published, in recognized technical journals, in the fields of modal acoustic examination methods.

- 4.5 A qualified tester shall be certified to Level II in accordance with *CAN/CGSB-48.9712-2014 / (ISO 9712:2012, IDT)*, *ANSI/ASNT CP-189-2011*, or *SNT-TC-1A-2016*, and shall be a person who has at least:
- a) two years continuous experience of a technical nature involving cylinders or tubes;
 - b) 40 hours of training or instruction in modal acoustic examination of tubes or other pressure vessels; and
 - c) 40 hours of experience in modal acoustic examination of tubes under the supervision of an SRT.
- 4.6 The MAE operator shall be capable of examining waveforms event by event and the waveforms for each event shall precisely correspond with the pressure and time data during the test.
- 4.7 The SRT shall prepare and submit the records required in section 5 of Appendix A of this equivalency certificate and annually verify that the MAE program is being operated in accordance with the requirements of the equivalency certificate.
- 4.8 The most recent copies of certification (e.g. ASNT Level or PE license) shall be available for inspection at each requalification facility.

5. RECORDS

A record shall be prepared documenting the examination conditions and requalification results including:

- a) a reference to this certificate number;
- b) the name of tube owner or operator;
- c) the name of the qualified SRT who performed or supervised the modal acoustic examination, as well as the MAE operator's name and certification level and the identification of the persons who performed the external visual inspection, as applicable;
- d) the tube serial number;
- e) the name or registered mark of the manufacturer;
- f) the MAE test pressure;
- g) the sensor configuration;
- h) the pressurization medium;
- i) the equivalency certificate to which the tube was manufactured and its marked service pressure;

Equivalency Certificate SH 13911
(Approval issued by the competent authority of Canada)

- j) the tube water capacity;
- k) the event energies exceeding the fiber tow fracture failure criteria (if applicable);
- l) the event energies exceeding the fretting emission energy allowable criteria (if applicable);
- m) the background energy oscillation pressure (if applicable);
- n) the background energy rise (if applicable);
- o) the requalification facility location;
- p) the requalification date;
- q) the external visual inspection results (pass/fail);
- r) the tube disposition (pass/fail);
- s) the previous examination date and previous test pressure;
- t) a record of system calibration before and after tube acoustic examination.

6. MARKING

Each tube requalified according to this equivalency certificate shall be marked in accordance with Clause 21.1 of *CSA B341-18*. The marking shall be applied on a tamper resistant label securely affixed to the dome of the tube and protected with a damage resistant cover. Stamping of any part of the tube is prohibited.

When a tube is required to be condemned, a label with the word "CONDEMNED" overcoated with epoxy shall be securely affixed to the tube.