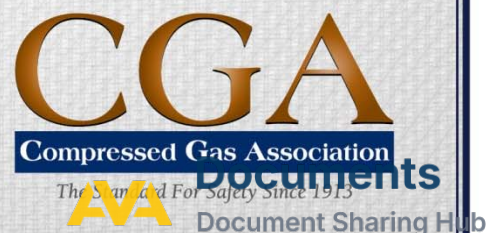


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**CGA C-18—2019**

**METHODS FOR ACOUSTIC  
EMISSION REQUALIFICATION OF  
SEAMLESS STEEL  
COMPRESSED GAS TUBES**

**FOURTH EDITION**



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Work Item 17-022  
Cylinder Specifications Committee

NOTE—Technical changes from the previous edition are underlined.

NOTE—Appendices A and C (Normative) are requirements.

NOTE—Appendix B (Informative) is for information only.

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## 1 Introduction

This publication is prepared to identify and describe the various acceptable acoustic emission (AE) test methods that may be used in lieu of hydrostatic test in the water jacket to requalify certain tubes as mandated by Title 49 of the U.S. *Code of Federal Regulations* (49 CFR) Part 180 Subpart C or Transport Canada (TC) *Transportation of Dangerous (TDG) Regulations* [1, 2].<sup>1</sup>

In the United States, the U.S. Department of Transportation (DOT) has approved and issued special permits that authorize an AE test combined with a nondestructive follow-up test (for example, shearwave ultrasonic examination [UE]) to be accomplished in lieu of hydrostatic test on certain compressed gas tubes [3]. In Canada, TC has approved and issued equivalency certificates that authorize AE testing combined with a nondestructive follow-up test to be performed in lieu of the hydrostatic water jacket test [4]. See Appendix A for TC equivalency certificates and DOT special permits [3, 4].

## 2 Scope

This publication provides guidelines for the AE testing of certain specification tubes as authorized by special permits and equivalency certificates such as those listed in Appendix A [3, 4].

Two methods of AE testing are addressed: method A and method B. Method A, which is approved in the United States by DOT and in Canada by TC, consists of an AE test performed during pneumatic pressurization to at least 110% of the normal fill pressure or marked service pressure, whichever is greater. This requalification test replaces the water jacket hydrostatic test. Method B, which is approved in Canada, consists of an AE test performed during the hydrostatic proof pressurization to the requalification pressure of the tube.

NOTE—Both methods A and B require additional ultrasonic verification of AE indications depending on the operational criteria defined in the applicable special permit or equivalency certificate [3, 4].

## 3 Definitions

For the purpose of this publication, the following definitions apply.

### 3.1 Publication terminology

#### 3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

#### 3.1.2 Should

Indicates that a procedure is recommended.

#### 3.1.3 May

Indicates that the procedure is optional.

#### 3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

#### 3.1.5 Can

Indicates a possibility or ability.

### 3.2 Technical definitions

#### 3.2.1 Acoustic emission

Phenomena whereby transient elastic waves are generated by the rapid release of energy from a localized source or sources within a material, or the transient elastic wave(s) so generated.

NOTE—Acoustic emission is the recommended term for general use. Other terms that have been used in AE literature include stress wave emission, microseismic activity, and emission or acoustic emission with other qualifying modifiers.

<sup>1</sup> References are shown by bracketed numbers and are listed in order of appearance in the reference section.

**3.2.2 AE dB**

Decibel scale used for expressing AE signal amplitudes.

NOTE—The 0 dB reference point for this scale is defined as an AE signal amplitude of 1 microvolt at the piezoelectric sensing element.

**3.2.3 AE detection**

Recognition of the presence of an AE signal (typically accomplished by a sensor voltage output exceeding the AE signal processor threshold).

**3.2.4 AE event (source location)**

AE hits detected at two or more channels, which can be used to calculate the location of the AE source through the linear location algorithm.

NOTE—An AE event, by definition, shall produce an AE hit at a minimum of two sensors.

**3.2.5 AE event cluster**

Occurrence of a specified number of AE events located within a limited area of the tube that could indicate the presence of a flaw; AE event clusters shall be subjected to follow-up inspection with UE.

**3.2.6 AE hit**

Set of AE data resulting from the detection of an AE signal by the AE signal processor; AE data shall include arrival time, amplitude, and tube pressure. For narrow band techniques, measured AE parameters shall also include threshold crossing counts, AE amplitude, and duration of each event.

NOTE—This additional data also may be measured for wideband techniques.

**3.2.7 AE test pressure**

Maximum pressure at which AE testing is performed.

**3.2.8 AE signal**

Voltage-time signal resulting from the passing of a stress wave under an AE sensor.

**3.2.9 AE signal processor threshold**

Voltage level above which AE signals are detected.

NOTE—AE signal processor threshold is an adjustable instrumentation setting.

**3.2.10 AE source**

Physical mechanism that produces AE.

NOTE—Primary sources (for example, flaw growth), secondary sources (for example, fracture of entrapped mill scale), and background noise (for example, mechanical contact) are all included.

**3.2.11 AE test range**

Range of pressure during which AE testing is monitored.

**3.2.12 AE testing**

Nondestructive testing (NDT) method involving the detection of elastic stress waves from flaws.

**3.2.13 AE waveform simulator**

Electronic device designed to produce a voltage-time signal similar to that of a typical AE signal.

NOTE—An AE waveform simulator or function generator can be used to perform routine electronic evaluation of the AE signal processor.

**3.2.14 Attenuation**

Loss of AE signal amplitude with distance traveled.

**3.2.15 Critical crack depth**

Maximum depth a crack achieves before unstable growth occurs.

**3.2.16 Flaw**

Imperfection or discontinuity that may or may not be acceptable based upon established acceptance/rejection criteria (for example, corrosion, scratches, cracks, cuts, gouges, or pits).

NOTE—See Section 5 for further information concerning flaws. The complete listing of current standard definitions relating to AE can be found in [ASTM E1316](#), *Standard Terminology for Nondestructive Examinations* [5].

**3.2.17 Marked service pressure**

Pressure for which a tube is designed.

NOTE—This pressure value is usually stamped on the shoulder of the tube at the time of manufacture.

**3.2.18 Maximum allowable flaw size**

Maximum flaw depth that is acceptable in a tube.

NOTE—See Section 15 for additional information on maximum allowable flaw size.

**3.2.19 Nondestructive testing (NDT)**

Test methodologies that detect flaws without destroying or altering the materials.

NOTE—Also known as nondestructive evaluation (NDE).

**3.2.20 Normal fill pressure**

Pressure to which a tube is filled in service.

NOTE—It can be greater than or less than the marked service pressure and is influenced by temperature.

**3.2.21 Peak amplitude (AE signal amplitude)**

Highest voltage of the excursion attained by the signal waveform from an AE hit.

NOTE—This voltage is expressed in decibels, referenced to 1 (one) microvolt at the pre-amplifier input (0 dB = 1 microvolt).

**3.2.22 Tubes**

Seamless container of cylindrical shape with openings at both ends and a water capacity greater than 450 L.

NOTE—Also described by TC's *TDG Regulations* as a container with a water capacity greater than 450 L, in a seamless cylindrical form, and capable of withstanding an internal service pressure of at least 12.4 MPa [2].

**3.2.23 Ultrasonic examination (UE)**

Nondestructive method that uses high frequency sound waves to examine material.

NOTE—Also known as ultrasonic testing (UT).

**4 Safety considerations**

The testing methods in this publication involve the use of high pressure equipment, and it is not within the scope of this publication to address all of the safety and health considerations therewith associated. It is the responsibility of the user to ensure that the appropriate safety regulations and publications are adhered to and the appropriate safety precautions are used.

**5 Flaws in gas tubes****5.1 Types of flaws (typical)**

Typical types of flaws are fatigue crack, corrosion, pitting, lap, and manufactured.

If a flaw is present, it can grow to critical size by metal fatigue (see 3.2.15). An example of a fatigue crack in a DOT-3AA tube is pictured in Figure 1. When tubes are manufactured, laps (or folds) are sometimes present. A section through one of these (in a DOT-3T tube) is pictured in Figure 2. Sometimes such flaws are not detected at time of manufacture. Once in service, flaws can grow under the influence of cyclic loads such as loads caused by filling tubes with gas and emptying them. A section through a severe flaw (in a DOT-3T tube) is shown in