Designation: E 1419 – 02

An American National Standard

Standard Test Method for Examination of Seamless, Gas-Filled, Pressure Vessels Using Acoustic Emission[1]

This standard is issued under the fixed designation E 1419; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method provides guidelines for acoustic emission (AE) examinations of seamless pressure vessels (tubes) of the type used for distribution or storage of industrial gases.

1.2 This test method requires pressurization to a level greater than normal use. Pressurization medium may be gas or liquid.

1.3 This test method does not apply to vessels in cryogenic service.

1.4 The AE measurements are used to detect and locate emission sources. Other nondestructive test (NDT) methods must be used to evaluate the significance of AE sources. Procedures for other NDT techniques are beyond the scope of this test method. See Note 1.

NOTE 1—Shear wave, angle beam ultrasonic inspection is commonly used to establish circumferential position and dimensions of flaws that produce AE.

1.5 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 7.

2. Referenced Documents

2.1 *ASTM Standards:*

A 388/A 388M Practice for Ultrasonic Examination of Heavy Steel Forgings[2]

E 543 Practice for Agencies Performing Nondestructive Testing[3]

E 650 Guide for Mounting Piezoelectric Acoustic Emission Sensors[3]

E 976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response[3]

E 1316 Terminology for Nondestructive Examinations[3]

2.2 *ASNT Standards:*[4]

SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification and Certification

ANSI/ASNT CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel

2.3 *Code of Federal Regulations:*

Section 49, Code of Federal Regulations, Hazardous Materials Regulations of the Department of Transportation, Paragraphs 173.34, 173.301, 178.36, 178.37, and 178.45[5]

2.5 *Compressed Gas Association Standard:*

Pamphlet C-5 Service Life, Seamless High Pressure Cylinders[6]

3. Terminology

3.1 *Definitions*—See Terminology E 1316 for general terminology applicable to this test method.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *fracture critical flaw*—a flaw that is large enough to exhibit unstable growth at service conditions.

3.2.2 *marked service pressure*—pressure for which a vessel is rated. Normally this value is stamped on the vessel.

3.2.3 *normal fill pressure*—level to which a vessel is pressurized. This may be greater, or may be less, than *marked service pressure*.

4. Summary of Test Method

4.1 The AE sensors are mounted on a vessel, and emission is monitored while the vessel is pressurized above normal fill pressure.

4.2 Sensors are mounted at each end of the vessel and are connected to an acoustic emission signal processor. The signal processor uses measured times of arrival of emission bursts to determine linear location of emission sources. If measured emission exceeds a prescribed level (that is, specific locations produce enough events), then such locations receive secondary

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[2] *Annual Book of ASTM Standards*, Vol 01.05.

[3] *Annual Book of ASTM Standards*, Vol 03.03.

[4] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

[5] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

[6] Available from Compressed Gas Association, Inc., 1235 Jefferson Davis Highway, Arlington, VA 22202.

(for example, ultrasonic) examination.

4.3 Secondary examination establishes presence of flaws and measures flaw dimensions.

4.4 If flaw depth exceeds a prescribed limit (that is, a conservative limit that is based on construction material, wall thickness, fatigue crack growth estimates, and fracture critical flaw depth calculations), then the vessel must be removed from service.

5. Significance and Use

5.1 Because of safety considerations, regulatory agencies (for example, U.S. Department of Transportation) require periodic tests of vessels used in transportation of industrial gases (see Section 49, Code of Federal Regulations). The AE testing has become accepted as an alternative to the common hydrostatic proof test. In the common hydrostatic test, volumetric expansion of vessels is measured.

5.2 An AE test should not be used for a period of one year after a common hydrostatic test. See Note 2.

NOTE 2—The Kaiser effect relates to decreased emission that is expected during a second pressurization. Common hydrostatic tests use a relatively high test pressure (167 % of normal service pressure). (See Section 49, Code of Federal Regulations.) If an AE test is performed too soon after such a pressurization, the AE results will be insensitive to a lower test pressure (that is, the lower pressure that is associated with an AE test).

5.3 *Pressurization*:

5.3.1 General practice in the gas industry is to use low pressurization rates. This practice promotes safety and reduces equipment investment. The AE tests should be performed with pressurization rates that allow vessel deformation to be in equilibrium with the applied load. Typical current practice is to use rates that approximate 500 psi/h (3.45 MPa/h).

5.3.2 Gas compressors heat the pressurizing medium. After pressurization, vessel pressure may decay as gas temperature equilibrates with ambient conditions.

5.3.3 Emission from flaws is caused by flaw growth and secondary sources (for example, crack surface contact and contained mill scale). Secondary sources can produce emission throughout vessel pressurization.

5.3.4 When pressure within a vessel is low, and gas is the pressurizing medium, flow velocities are relatively high. Flowing gas (turbulence) and impact by entrained particles can produce measurable emission. Considering this, acquisition of AE data may commence at some pressure greater than starting pressure (for example, ⅓of maximum test pressure).

5.3.5 *Maximum Test Pressure*—Serious flaws usually produce more acoustic emission (that is, more events, events with higher peak amplitude) from secondary sources than from flaw growth. When vessels are pressurized, flaws produce emission at pressures less than normal fill pressure. A maximum test pressure that is 10 % greater than normal fill pressure allows measurement of emission from secondary sources in flaws and from flaw growth.

5.3.6 *Pressurization Schedule*—Pressurization should proceed at rates that do not produce noise from the pressurizing medium and that allow vessel deformation to be in equilibrium with applied load. Pressure holds are not necessary; however, they may be useful for reasons other than measurement of AE.

5.4 Excess background noise may distort AE data or render them useless. Users must be aware of the following common sources of background noise: high gas-fill rate (measurable flow noise); mechanical contact with the vessel by objects; electromagnetic interference (EMI) and radio frequency interference (RFI) from nearby broadcasting facilities and from other sources; leaks at pipe or hose connections; and airborne sand particles, insects, or rain drops. This test method should not be used if background noise cannot be eliminated or controlled.

6. Basis of Application

6.1 *Personnel Qualification*—The NDT personnel shall be qualified in accordance with a nationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT CP-189, SNT-TC-1A, or a similar document. The practice or standard used and its applicable revision shall be specified in the contractual agreement between the using parties.

6.2 *Qualification of Nondestructive Testing Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice E 543. The applicable edition of Practice E 543 shall be specified in the contractual agreement.

6.3 *Time of Examination*—The time of examination shall be in accordance with 5.2 unless otherwise specified.

6.4 *Procedures and Techniques*—The procedures and techniques to be used shall be as described in this test method unless otherwise specified. Specific techniques may be specified in the contractual agreement.

6.5 *Extent of Examination*—The extent of examination shall be in accordance with 4.2 and 10.9 unless otherwise specified.

7. Apparatus

7.1 Essential features of the apparatus required for this test method are provided in Fig. 1. Full specifications are in Annex A1.

7.2 Couplant must be used to acoustically connect sensors to the vessel surface. Adhesives that have acceptable acoustic

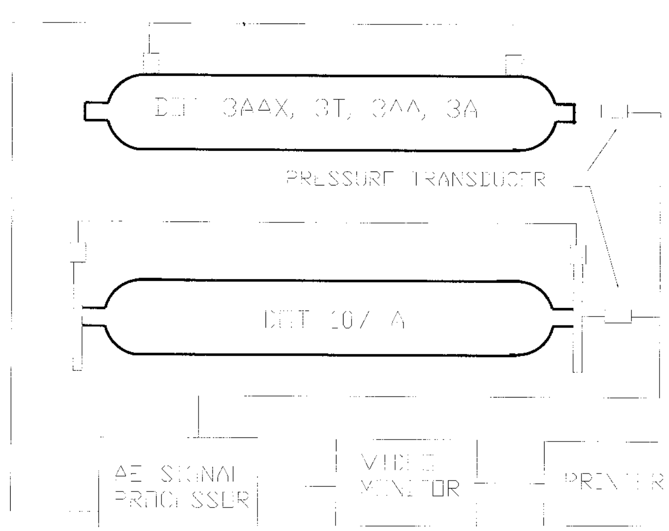

FIG. 1 Essential Features of the Apparatus

properties, and adhesives used in combination with traditional couplants, are acceptable.

7.3 Sensors may be held in place with magnets, adhesive tape, or other mechanical means.

7.4 The AE sensors are used to detect strain-induced stress waves produced by flaws. Sensors must be held in contact with the vessel wall to ensure adequate acoustic coupling.

7.5 A preamplifier may be enclosed in the sensor housing or in a separate enclosure. If a separate preamplifier is used, cable length, between sensor and preamp, must not exceed 6 ft (1.83 m).

7.6 Power/signal cable length (that is, cable between preamp and signal processor) shall not exceed 500 ft (152.4 m). See A1.5.

7.7 Signal processors are computerized instruments with independent channels that filter, measure, and convert analog information into digital form for display and permanent storage. A signal processor must have sufficient speed and capacity to independently process data from all sensors simultaneously. The signal processor should provide capability to filter data for replay. A printer should be used to provide hard copies of test results.

7.7.1 A video monitor should display processed test data in various formats. Display format may be selected by the equipment operator.

7.7.2 A data storage device, such as a floppy disk, may be used to provide data for replay or for archives.

7.7.3 Hard copy capability should be available from a graphics/line printer or equivalent device.

8. Safety Precautions

8.1 As in any pressure test of metal vessels, ambient temperature should not be below the ductile-brittle transition temperature of the pressure vessel construction material.

9. Calibration and Standardization

9.1 Annual calibration and verification of pressure transducer, AE sensors, preamplifiers (if applicable), signal processor (particularly the signal processor time reference), and AE electronic waveform generator should be performed. Equipment should be adjusted so that it conforms to equipment manufacturer's specifications. Instruments used for calibrations must have current accuracy certification that is traceable to the National Institute for Standards and Technology (NIST).

9.2 Routine electronic evaluations must be performed any time there is concern about signal processor performance. An AE electronic waveform generator should be used in making evaluations. Each signal processor channel must respond with peak amplitude reading within ±2 dBV of the electronic waveform generator output.

9.3 A system performance check must be conducted immediately before, and immediately after, each examination. A performance check uses a mechanical device to induce stress waves into the vessel wall at a specified distance from each sensor. Induced stress waves stimulate a sensor in the same way as emission from a flaw. Performance checks verify performance of the entire system (including couplant).

9.3.1 The preferred technique for conducting a performance check is a pencil lead break (PLB). Lead should be broken on the vessel surface more than 4.0 in. (10.16 cm) from the sensor. The 2H lead, 0.3-mm diameter, 3-mm long should be used (see Fig. 4 of Guide E 976).

9.3.2 Auto Sensor Test (AST). An electromechanical device such as a piezoelectric pulser (and sensor which contains this function) can be used in conjunction with pencil lead break (9.3.1) as a means to assure system performance. This device can be used to replace the PLB post test, system performance check (9.3).

10. Procedure

10.1 Visually examine accessible exterior surfaces of the vessel. Note observations in test report.

10.2 Isolate vessel to prevent contact with other vessels, hardware, and so forth. When the vessel cannot be completely isolated, indicate, in the test report, external sources which could have produced emission.

10.3 Connect fill hose and pressure transducer. Eliminate any leaks at connections.

10.4 Mount an AE sensor at each end of each tube. Use procedures specified in Guide E 650. Sensors must be at the same angular position and should be located at each end of the vessel so that the AE system can determine axial locations of sources in as much of the vessel as possible.

10.5 Adjust signal processor settings. See Appendix X1 for example.

10.6 Perform a system performance check at each sensor (see 9.3). Verify that peak amplitude is greater than a specified value (see Table X1.2). Verify that the AE system displays a correct location (see Note 3) for the mechanical device that is used to produce stress waves (see 9.4 and Table X1.2). Prior to pressurization, verify that there is no background noise above the signal processor threshold setting.

NOTE 3—If desired location accuracy cannot be attained with sensors at two axial locations, then more sensors should be added to reduce sensor spacing.

10.7 Begin pressurizing the vessel. The pressurization rate shall be low enough that flow noise is not recorded.

10.8 Monitor the examination by observing displays that show plots of AE events versus axial location. If unusual response (in the operator's judgment) is observed, interrupt pressurization and conduct an investigation.

10.9 Store all data on mass storage media. Stop the examination when the pressure reaches 110 % of normal fill pressure or 110 % of marked service pressure (whichever is greater). The pressure shall be monitored with an accuracy of ±2 % of the maximum test pressure.

10.9.1 *Examples*:

10.9.1.1 A tube trailer is normally filled to a gage pressure of 2640 psi (18.20 MPa). Pressurization shall stop at 2904 psi (20.02 MPa).

10.9.1.2 A gas cylinder is normally filled to a gage pressure of 613 psi (4.23 MPa). The marked service pressure is 2400 psi (16.55 MPa). Pressurization shall stop at 2640 psi (18.20 MPa).

10.10 Perform a system performance check at each sensor (see 9.3). Verify that peak amplitude is greater than a specified value (see Table X1.2).

10.11 Reduce pressure in vessel to normal fill pressure by