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Standard Practice for Acoustic Emission Examination of High Pressure, Low Carbon, Forged Piping using Controlled Hydrostatic Pressurization[1]

This standard is issued under the fixed designation E2984/E2984M; 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1.1 This practice is no longer being updated but is being retained for historical value as it represents the only AE practice using hydrostatic testing in which the sensors are not in direct contact with the part.

1.2 In the preferred embodiment, this practice examines immersed low carbon, forged piping being immersed in a water tank with the acoustic sensors permanently mounted on the tank walls rather than temporarily on the part itself. The pipes are monitored while being internally loaded (stressed) by hydrostatic means up to 1000 bar.

1.3 This practice examines either an immersed pipe, or non-immersed pipe being stressed by internal hydrostatic means to create acoustic emissions when cracks are present. However, the non-immersed method is time consuming, requiring placement and removal of sensors for each pipe inspected, while the immersed method has sensors permanently mounted, providing consistent sensor coupling to the tank-eliminating reinstallation. The non-immersed method is not recommended for the specified reasons and only the immersed method will be discussed throughout the remainder of the ~~standard.~~practice. This is similar to pressure vessel testing described in Practice E569, but uses hydrostatic means not included in that standard.

1.4 This Acoustic Emission (AE) method addresses examination for monitoring low carbon, forged piping systems being internally loaded (stressed) by hydrostatic means up to 1000 bar [15,000 psi] while being immersed in a water bath to facilitate sensor coupling.

1.5 The basic functions of an AE monitoring system are to detect, locate, and classify emission sources. Other methods of nondestructive testing (NDT) may be used to further evaluate the significance of acoustic emission sources.

1.6 This practice can be used to replace visual methods, which are unreliable and have significant safety risks.

1.7 This practice describes procedures to install and monitor acoustic emission resulting from local anomalies stimulated by controlled hydrostatic pressure.

1.8 Other methods of nondestructive testing (NDT) may be used to further evaluate the significance of acoustic emission sources.

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[1] This ~~test method~~ practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.04 on Acoustic Emission Method.

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1.9 _Units—_The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.10 *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.11 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E543 Specification for Agencies Performing Nondestructive Testing
E569 Practice for Acoustic Emission Monitoring of Structures During Controlled Stimulation
E650 Guide for Mounting Piezoelectric Acoustic Emission Sensors
E750 Practice for Characterizing Acoustic Emission Instrumentation
E976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response
E1316 Terminology for Nondestructive Examinations
E2374 Guide for Acoustic Emission System Performance Verification

2.2 *Other Referenced Documents*

ANSI/ASNT CP-189 Standard for Qualification and Certification of Nondestructive Testing Personnel[3]
NAS-410 NDT Certification[4]
SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing[5]

3. Terminology

3.1 *Definitions*—Definitions of terms relating to acoustic emission may be found in Section B of Terminology E1316.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *AE ~~activity—~~activity, n—*the presence of acoustic emission during an examination.

3.2.2 *active ~~source—~~source, n—*one which exhibits increasing cumulative AE activity with increasing or constant stimulus.

3.2.3 *critical ~~source—~~source, n—*is where the event energy rate exceeds a baseline established from known good parts.

3.2.4 *critically intense ~~source—~~source, n—*one in which the AE source intensity consistently increases with increasing stimulus or with time under constant stimulus.

3.2.5 *hydrostatic ~~stimulation—~~stimulation, n—*applies stress internally to a pressure vessel stimulating any incipient defects to be in motion yielding stress or strain waves.

4. Summary of Practice

4.1 Acoustic emission examination of a structure usually requires application of a mechanical or thermal stimulus to produce changes in the stresses in the structure. In this application, the use of internal hydrostatic pressure, over an appropriate range, stimulates changes in the stresses in the structure. During this stimulation, AE from discontinuities (such as cracks, corrosion and inclusions), or from other acoustic sources (such as leaks or structural motion) can be detected by an AE instrument, using sensors which, when stimulated by stress waves, generate electrical signals.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.
[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.
[4] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.
[5] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

4.2 In addition to immediate, real time, evaluation of the emissions detected during the application of the stimulus, a permanent record of the number and location of emitting sources and the relative amount of AE detected from each source provides a basis for comparison with sources detected during the examination and during subsequent stimulation. This may be used to discriminate between AE events emitting from corrosion and those from the more serious cracks.

5. Significance and Use

5.1 High pressure fluids being pumped in all oil field applications often stress iron pipes where subsequent failure can lead to injury to personnel or equipment. These forgings are typically constructed from 4700 series low carbon steel with a wall thickness in excess of 1.25 cm [0.5 in.], dependent on the manufacturers' specification. The standard method to certify that these iron segments can withstand operational pressures is to perform dye penetrant (PT) or magnetic particle penetrant (MT) tests, or both, to reveal defects (cracks and corrosion). As these methods are subject to interpretation by the human eye, it is desirable to employ a technique whereby a sensor based system can provide a signal to either pass or fail the test object. To that end, the acoustic emission (AE) method provides the requisite data from which acceptance/rejection can be made by a computer, taking the human out of the loop, providing that a human has correctly programmed the acceptance criteria. Most of these pipe segments are not linear, thus a 3D defect location method is desirable. The 3D source indication represents the spatial location of the defect without regard to its orientation, recognizing the source location is only approximate due to sound propagation through the part and water bath.

5.2 The immersed 3D approach is found to be preferable due to the large number of parts to be examined. The 3D system is easily replicated and standardized in that all sensor locations are fixed to the exterior of the fluid bath. Multiple parts may be easily placed into an assembly, allowing all to be examined in a single test, thus accelerating throughput. Attaching a minimum of eight AE sensors to the tank enhances the probability that a sufficient number of AE hits in an event will occur, allowing for an approximate location determination. When an indication of a defect is observed, the subject part is identified by the spatial location allowing it to be removed for further examination, or rejected for service. An immersed test configuration is shown in Fig. 1a and b.

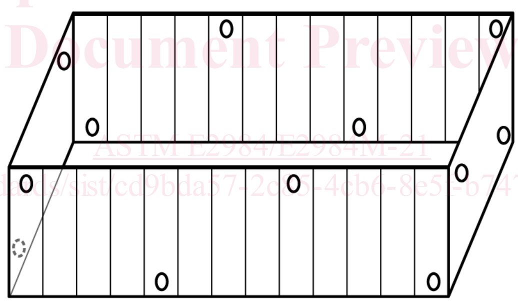

FIG. 1 (a) Immersion ~~bath with permanently attached AE sensors on exterior (circles)~~Bath With Permanently Attached AE Sensors on Exterior (Circles)

FIG. 1 (b) ~~photo of part under test~~Photo of Part Under Test *(continued)*

5.3 The non-immersed examination is equally effective in detecting defects, but requires more time to assemble in that sensors must be attached to the part for each examination. Moreover, the fluid fill and air purge times are much longer than in the immersed bath immersion. The non-immersed test layout and photo are shown in Fig. 2a and b. Note the sensors are indicated with the symbol *x*.

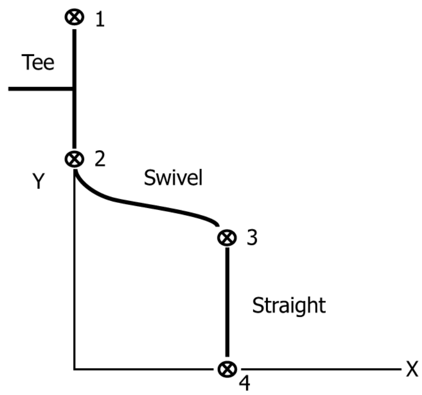

FIG. 2 (a) ~~is~~Is the ~~layout, with~~Layout, With sensors 1–4, of ~~a typical non-immersed test~~A Typical Non-immersed Test as is ~~shown~~Shown in the ~~photo~~Photo (b)

FIG. 2 (b) Sensors 1–4, of ~~a typical non-immersed test~~A Typical Non-immersed Test *(continued)*

6. Basis of Application

6.1 The following items are subject to contractual agreement between the parties using or referencing this practice.

6.2 *Personnel Qualification*

6.2.1 If specified in the contractual agreement, personnel performing examinations to this ~~standard~~practice shall be qualified in accordance with a nationally and internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT CP-189, SNT-TC-1A, NAS-410, or similar as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

6.3 *Qualification of Nondestructive Testing Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in ~~Practice~~Specification E543. The applicable edition of ~~Practice~~Specification E543 shall be specified in the contractual agreement.

6.4 *Timing of Examination*—The timing of the examination shall be in accordance with a contractual agreement or with an established internal procedure.

6.5 *Extent of Examination*—This application requires sensor(s) placement such that the location where an AE event occurs can be reliably detected.

6.6 *Reporting Criteria/Acceptance*—Reporting criteria for the examination results shall be in accordance with Sections 11, 12, and 13.

6.7 *Reexamination of Repaired/Reworked Items*—Reexamination of repaired or reworked items is not addressed in this ~~standard~~practice and if required shall be specified in a contractual agreement.

7. Examination Preparation

7.1 Before the examination begins, make the following preparations for AE monitoring:

7.1.1 *Sensor ~~requirements—~~Requirements—*Consideration should be given to the fact that multiple pieces of treating iron will be tested simultaneously. The type, number, and placement of sensors is critical in that source location will be used to determine which pieces are emitting during a hydrotest. Three dimensional source location is ideal for this application if used properly.

7.1.1.1 This requires knowledge of materials and physical characteristics of the structure being tested as well as the liquid-filled container in which they are tested. It also requires knowledge of wave propagation through a liquid as well as the instrumentation used to collect and process these waves. Knowledge of overdetermined source location is also helpful.

7.1.1.2 This determination is also dependent upon the required precision and the accuracy of examination. It is important to use an appropriate number of sensors to provide sufficiently accurate 3D source location to distinguish which piece of iron is generating significant AE.

7.1.1.3 No fewer than eight sensors are desirable for an immersion tank that is 10 ft. long by 5 ft. wide by 5 ft. deep.

7.1.1.4 Tanks with dimensions greater than these (for accommodating multiple pieces of treating iron) will require more sensors to instrument.

7.1.2 The immersion tank shell (walls) shall be constructed from stainless steel to avoid corrosion. This allows for a permanent attachment of all AE sensors defining a stable 3D location geometry. The water holding tank shall be no smaller than 400 cm [13 ft.] long by 150 cm [5 ft.] wide by 90 cm [3 ft.] tall, with 25 cm [10 in.] legs and levelers to raise the height to be a comfortable working height and accommodate a roll under crane for loading and unloading pipes. These dimensions allow the loading of multiple components for a simultaneous examination. The water bath is specified to be distilled with a corrosion inhibitor added.

7.1.3 An appropriate AE sensor with a frequency range from 150 to 450 kHz shall be employed to avoid ambient noise sources.

7.1.4 Establish communications between the control point for the application of the stimulus and the AE examination control center.

7.1.5 Provide a means for continuously recording a measure of the stimulus.

7.1.6 Identify potential sources of extraneous acoustic noise, such as vibration, friction, and fluid flow. Such sources may require acoustic isolation or control, in order not to mask valid acoustic emissions.

7.1.7 Attach the sensors; both the couplant and sensing device must be compatible with the surface conditions and the composition of the structural material being examined (see Guide E650).

7.1.8 Verify the AE monitoring system in accordance with Section 9 and Guide E2374.

7.1.9 A training set of multiple known "good" and "defective" pieces as previously determined by Magnetic Particle Inspection (MT) or Fluorescent Penetrant Inspection (PT) are examined by this method. These data establish a baseline for future comparisons to define acceptable/reject parts, as this method is applicable to the repetitive examination of large sets of parts on a periodic basis, and not for one time testing of unique structures.

7.1.10 AE methods can be applied to detect potential critical defects in high pressure piping, however 3D has an intrinsic advantage in that cracks can be separated from other AE sources using location detection algorithms.