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

1. Scope

1.1 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.

1.2 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. This is similar to pressure vessel testing described in Practice E569, but uses hydrostatic means not included in that standard.

1.3 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.

1.4 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.

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

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

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

1.8 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.9 *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.*

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]

[1] This test method 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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[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.

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*—the presence of acoustic emission during an examination.

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

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

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

3.2.5 *hydrostatic stimulation*—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.

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.

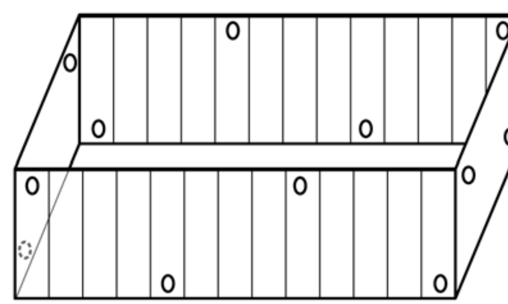

FIG. 1 (a) Immersion bath with permanently attached AE sensors on exterior (circles)

FIG. 1 (b) 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

[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.