Designation: E1139/E1139M – 17

Standard Practice for Continuous Monitoring of Acoustic Emission from Metal Pressure Boundaries[1]

This standard is issued under the fixed designation E1139/E1139M; 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 provides guidelines for continuous monitoring of acoustic emission (AE) from metal pressure boundaries in industrial systems during operation. Examples are pressure vessels, piping, and other system components which serve to contain system pressure. Pressure boundaries other than metal, such as composites, are specifically not covered by this document.

1.2 The functions of AE monitoring are to detect, locate, and characterize AE sources to provide data to evaluate their significance relative to pressure boundary integrity. These sources are those activated during system operation, that is, no special stimulus is applied to produce AE. Other methods of nondestructive testing (NDT) may be used, when the pressure boundary is accessible, to further evaluate or substantiate the significance of detected AE sources.

1.3 *Units*—The values stated in either SI units or inch-pound units are to be regarded 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 standards.

1.4 *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.* For specific precautionary statements, see Section 6.

1.5 *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 *Aerospace Industries Association:*[3]

NAS-410 Certification and Qualification of Nondestructive Testing Personnel

2.3 *Other Documents:*[4]

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

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

2.4 *ISO Standard:*[5]

ISO 9712 Non-Destructive Testing: Qualification and Certification of NDT Personnel

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this practice, refer to Terminology E1316.

[1] This 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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[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 Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.

[4] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

*A Summary of Changes section appears at the end of this standard

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *continuous monitoring*—the process of monitoring a pressure boundary continuously to detect acoustic emission during system operation and also during system shut-down testing such as hydrostatic testing.

3.2.2 *raw data*—data values determined directly from measurement of analog inputs. These could include emission count or emission event count, or both, relative time of signal arrival at different sensors (delta time), signal rise time, peak signal amplitude, RMS signal level, pressure system pressure and temperature, and the like.

3.2.3 *processed data*—data resulting from analysis of raw data. Included would be AE source location coordinates, AE versus time from a given source area, AE signal amplitude versus time, and the like.

4. Summary of Practice

4.1 This practice describes the use of a passive monitoring system to detect, locate, and characterize AE sources, in order to evaluate their significance to the integrity of metal pressure boundaries.

4.2 The practice provides guidelines for selection, qualification, verification, and installation of the AE monitoring system. Qualification of personnel is also addressed.

4.3 The practice provides guidelines for using the AE information to estimate the significance of a detected AE source with respect to continued pressure system operation.

5. Significance and Use

5.1 Acoustic emission examination of a structure requires application of a mechanical or thermal stimulus. In this case, the system operating conditions provide the stimulation. During operation of the pressurized system, AE from active discontinuities such as cracks or from other acoustic sources such as leakage of high-pressure, high-temperature fluids can be detected by an instrumentation system using sensors mounted on the structure. The sensors are acoustically coupled to the surface of the structure by means of a couplant material or pressure on the interface between the sensing device and the structure. This facilitates the transmission of acoustic energy to the sensor. When the sensors are excited by acoustic emission energy, they transform the mechanical excitations into electrical signals. The signals from a detected AE source are electronically conditioned and processed to produce information relative to source location and other parameters needed for AE source characterization and evaluation.

5.2 AE monitoring on a continuous basis is a currently available method for continuous surveillance of a structure to assess its continued integrity. The use of AE monitoring in this context is to identify the existence and location of AE sources. Also, information is provided to facilitate estimating the significance of the detected AE source relative to continued pressure system operation.

5.3 Source location accuracy is influenced by factors that affect elastic wave propagation, by sensor coupling, and by signal processor settings.

5.4 It is possible to measure AE and identify AE source locations of indications that cannot be detected by other NDT methods, due to factors related to methodological, material, or structural characteristics.

5.5 In addition to immediate evaluation of the AE sources, a permanent record of the total data collected (AE plus pressure system parameters measured) provides an archival record which can be re-evaluated.

6. Hazards

6.1 **Warning**—Application of this practice will inherently involve work in an operating plant. This may involve potential exposure to hazardous materials and equipment and, in the case of nuclear power plants, exposure to nuclear radiation. A written safety plan shall be prepared for each monitoring installation which defines requirements to be observed to protect personnel safety, safety of the plant system, and to meet administrative and legal needs. This plan shall be approved by all parties prior to start of work on the plant.

7. Basis of Application

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

7.2 *Personnel Qualification*

7.2.1 If specified in the contractual agreement, personnel performing examinations to this practice shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, NAS-410, ISO 9712, or a similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

7.3 *Qualification of Nondestructive Agencies*

7.3.1 If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice E543. The applicable edition of Practice E543 shall be specified in the contractual agreement.

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

7.5 *Timing of Examination*—The timing of examination shall be continuous, in accordance with 1.1 unless otherwise specified.

7.6 *Extent of Examination*—The extent of examination shall be that part of the pressure boundary in the coverage range of the mounted acoustic emission sensors, unless otherwise specified.

7.7 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with Section 14 unless otherwise specified. Since acceptance criteria (for example, for reference radiographs) are not specified in this practice, they shall be specified in the contractual agreement.

7.8 *Reexamination of Repaired/Reworked Items*—Reexamination of repaired/reworked items is not addressed in this practice and if required shall be specified in the contractual agreement.

7.9 Routine operation of the acoustic emission system for collection and a cursory review of the data may be performed by a competent plant engineer not necessarily specialized in acoustic emission. However, acoustic emission system operation and data interpretation should be verified by a qualified acoustic emission specialist on approximately six-month intervals or sooner if the system appears to be malfunctioning or the data appear unusual.

8. Monitoring System Functional Requirements and Qualification

8.1 *Functional Requirements:*

8.1.1 The monitoring system must include the functional capabilities shown in Fig. 1 which also shows a suggested sequence of monitoring system functions.

8.1.2 *Signal Detection*—The AE sensor together with the acoustic coupling to the structure must have sensitivity sufficient to detect AE signals while the pressure system is operating. In most cases, this determination must be performed when the pressure system is not operating. AE system response to normal operational noise, which must be considered here, is discussed in 9.1. One method of performing the required evaluation is to use a pencil lead break as a signal source. With the sensor in place and connected to the system, the response at the amplifier output to fracturing a 0.3-mm [0.012 in.] pencil lead against the surface being monitored, at a distance of 150 to 300 mm [6 to 12 in.] from the sensor should show a minimum signal-to-noise (electronic plus process noise) ratio of 4 to 1 in the frequency range suitable for the planned monitoring environment. A differential sensor should be considered to minimize interference from electronic transients. The sensor must be capable of withstanding the monitoring environment (temperature, moisture, nuclear radiation, mechanical vibration, and the like) for an extended period of continuous exposure. The minimum length of this period will be dictated by accessibility to the location to change sensors, and by economic considerations.

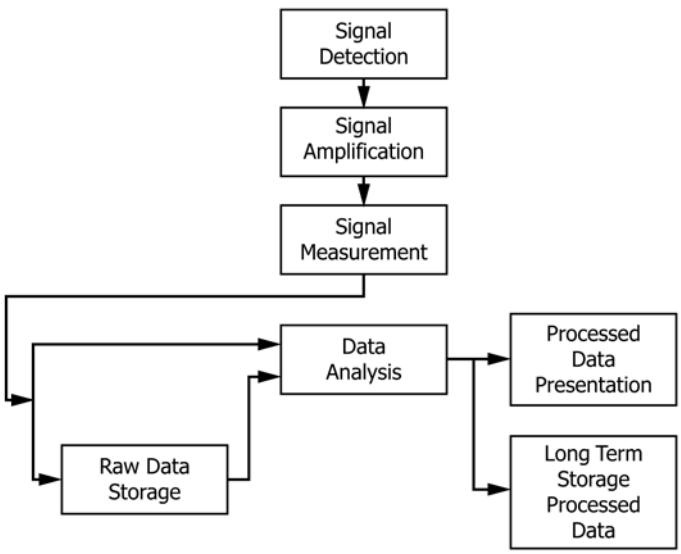

FIG. 1 Functional Flow Diagram—Continuous AE Monitoring System

8.1.3 *Signal Amplification*—For those AE systems that use gain adjustments, appropriate signal amplification in the range of 0 to 60 dB is usually required to achieve an adequate AE signal level for measurement of signal parameters in digital AE systems. Due to the very small magnitude of energy involved in an AE source, it is desirable to locate the signal amplification as near as possible to the output of the sensor. This is beneficial in controlling noise interference and AE signal transmission loss. These preamplifiers must have low inherent electronic background noise. Resistance of the amplifier circuits to the environment (temperature, moisture, nuclear radiation, mechanical vibration, and the like) must be considered and appropriate steps taken to protect them.

NOTE 1—When used herein, peak means zero to peak voltage.

8.1.4 *Monitoring Frequency Band*—The frequency response of the sensor or amplifier combination must be selected for the given application. The AE signal being a transient pulse is detectable over a broad range of frequencies. Because the acoustic attenuation in engineering materials is frequency dependent, it is desirable to use a low monitoring frequency (50 to 100 kHz) to maximize the distance from the AE source over which the AE event can be detected. The low end of the monitoring frequency will usually be controlled by the background noise present in the monitoring environment. In some applications such as operating nuclear reactors, the background noise may require a low frequency cut-off point of 400 to 500 kHz. In cases of severe continuous background noise, inductive tuning of the sensor at the preamplifier input may be effective. The high end of the frequency response band may be limited to 1.0 MHz to help reduce amplifier electronic noise.

8.1.5 *Signal Measurement:*

8.1.5.1 The signal measurement section will receive the fully-amplified analog signal. Generally its operation will be controlled by a voltage threshold circuit which will limit accepted data to that exceeding the voltage amplitude threshold. AE parameters measured may include AE count, AE event count, signal amplitude, time from threshold crossing to signal peak, signal duration, difference in time of signal arrival at various sensors making up a source location array, clock time, data, and the value of any process system parameters (temperature, pressure, strain, and the like) available to the AE monitoring system. If the AE monitoring system is to perform detection of pressure system leaks, it must measure the average signal level or AE rms voltage for each sensing channel.

8.1.5.2 It is desirable that the signal measurements include a function to assess the characteristics of an acoustic emission signal to determine if it matches those originating from crack growth. The function should provide a "flag" for those signals which have characteristics similar to those known to originate from crack growth as determined by an AE specialist.

8.1.5.3 The output from the signal measurement subsystem should be in digital form to facilitate storage of large quantities of data.