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Standard Guide for Acoustic Emission System Performance Verification[1]

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1. Scope

1.1 System performance verification methods stimulate the examination article on which the sensor is mounted. The resulting stress wave travels in the examination article and is detected by the sensor(s) in a manner similar to acoustic emission.

1.2 This guide describes methods which can be used to verify the response of an Acoustic Emission system including sensors, couplant, sensor mounting devices, cables and system electronic components.

1.3 Acoustic emission system performance characteristics, which may be evaluated using this document, include some waveform parameters, and source location accuracy.

1.4 Performance verification is usually conducted prior to beginning the examination.

1.5 Performance verification can be conducted during the examination if there is any suspicion that the system performance may have changed.

1.6 Performance verification may be conducted after the examination has been completed.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E750 Practice for Characterizing Acoustic Emission Instrumentation

E976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response

E1316 Terminology for Nondestructive Examinations

E1419 Practice for Examination of Seamless, Gas-Filled, Pressure Vessels Using Acoustic Emission

E1781 Practice for Secondary Calibration of Acoustic Emission Sensors

3. Terminology

3.1 *examination article*—the item which is being examined with AE and to which AE sensors are attached.

3.2 *velocity*—the measured velocity of a stress wave, traveling in the examination article, using specified AE system parameters and components. Velocity is often used in triangulation calculations to determine the position of the AE source.

3.3 *auto sensor test (AST)*—an electronic means by which a sensor can be fed an electronic pulse to excite the examination article. The resulting stress wave in the examination article can be measured by the same sensor or by other sensors that are on the same examination article. See 3.4 and 3.5.

3.4 *auto sensor test-self test mode*—a means by which an AST sensor may be used to check its own performance.

3.5 *auto sensor test-near neighbor mode*—a means by which an AST sensor may be used to determine the sensitivity of one or more neighboring sensors on the same examination article.

4. Significance and Use

4.1 Acoustic Emission data acquisition can be affected by numerous factors associated with the electronic instrumentation, cables, sensors, sensor holders, couplant, the examination article on which the sensor is mounted, background noise, and the user's settings of the acquisition parameters (for example, threshold).

4.2 This guide is not intended to replace annual (or semi-annual) instrumentation calibration (see Practice E750) or sensor recertification (see Practice E1781).

4.3 This guide is not intended to replace routine electronic evaluation of AE instrumentation or routine sensitivity verification of AE sensors (see Guide E976).

4.4 This guide is not intended to verify the maximum processing capacity or speed of an AE system.

4.5 This guide 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 guide to establish appropriate safety and

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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.

health practices and determine the applicability of regulatory limitations prior to use.

5. Apparatus

5.1 To determine system performance a sensor must be subjected to a stress wave traveling in the examination article. Transient stress waves are launched by mechanical or electromechanical devices that produce a waveform with fast rise-time, short duration and repeatable peak amplitude. Steady state (continuous) stress waves are launched by mechanical or electromechanical devices that produce a waveform with long duration constant amplitude.

5.1.1 *Pencil Lead Break (PLB)*—A mechanical pencil technique whereby lead is pushed against the examination article's surface with sufficient force to break the lead. When the lead breaks, there is a sudden release of stress on the surface. (See Guide E976, paragraph 4.3.3 and Fig. 4.)

5.1.1.1 The distance between the PLB and the sensor must be specified.

5.1.1.2 The "Hsu pencil source" uses a mechanical pencil with a 2.5 mm lead extension, 2H hardness and 0.3 mm or 0.5 mm diameter (0.3 mm is preferred).

5.1.1.3 The "Nielsen shoe" can aid in breaking the lead consistently.

5.1.1.4 The pencil should be held at an angle of 30 degrees to the surface.

5.1.1.5 Three to five lead breaks are generally conducted to show a consistent result.

5.1.1.6 Application standards (for example, Test Method E1419) specify the minimum signal amplitude that must be measured by the AE instrumentation.

5.1.1.7 Channels which are found to have unacceptably low or high sensitivity can be recoupled (that is, replace couplant), repaired (that is, replace sensor, or cable, or both), or replaced (that is, exchanged for another channel), or both.

5.1.1.8 PLB can be used to determine the apparent velocity in the examination article (apparent velocity = sensor spacing/time-of-flight). "Time-of-flight" is the time required for a stress wave to travel the sensor-spacing distance

5.1.2 *Independent Piezoelectric Pulser*—An electromechanical device held against the examination article and used in conjunction with an electronic signal or pulse generator. The electrical signal from the signal/pulse generator is converted into a mechanical displacement by the transducer's crystal. (See Guide E976, paragraph 4.3.1.) One significant advantage of this technique is that the output of the electronic signal/pulse generator can be adjusted in numerous ways (for example, amplitude and repetition rate).

5.1.2.1 The independent pulser can be used to excite the receiving AE sensor before, during and after an examination as verification that there were no changes in coupling or sensor response. The independent pulser technique is particularly useful when there is limited access to the examination article that would preclude the use of manual techniques (for example, PLB).

5.1.2.2 The independent pulser technique is particularly useful in continuous monitoring situations where sensors will be on the examination article for a long period of time. In this situation the independent pulser is left in place and used periodically to assure system performance.

5.1.3 *AST Capable Integrated Pulser/Sensor*—An AE sensor that has been designed to accept an electronic signal/pulse into its crystal. The mechanical displacement of the crystal excites the examination article. The stress wave generated in the examination article can be detected by other sensors on the same examination article. With certain realizations of the AST function (self test mode), it can also be detected by the exciting sensor.

5.1.3.1 *Auto Sensor Test: Near Neighbor Mode*—An integrated pulser/sensor can be used to measure sensitivity and time-of-flight (that is, the time required for a stress wave to travel the sensor-spacing distance) for neighboring sensors on the same examination article. The time-of-flight can be used to calculate the apparent velocity of the stress wave (apparent velocity = sensor spacing/time-of-flight).

5.1.3.2 *Auto Sensor Test: Self Test Mode*—An integrated pulser/sensor can be used to verify the performance of the sensor coupling and the sensor and channel electronics to which it is attached by establishing a baseline duration (or energy) measured from the AST pulse using a sensor that is known to be operating properly and mounted optimally on the examination article. The baseline duration number (for example, 10 000 µs) can then be compared with the AST duration measurements from each channel on the examination article. Channels, which produce AST duration measurements that are low compared to the baseline, should be recoupled, repaired or replaced as necessary.

5.1.4 *Spring Loaded Center Punch*—A spring loaded device that imparts a mechanical impact force, creating a very large stress wave on the examination article. The spring assures a consistent and repeatable force.

5.1.4.1 The spring-loaded center punch is of particular advantage when AE sensors are distributed over large distances on an examination article, as the imparted force is so strong it can be detected easily.

5.1.4.2 The spring-loaded center punch is readily available and easy to apply anywhere on the examination article, at any time.

5.1.4.3 To avoid damage to the surface, it is desirable to apply the center punch through an intermediate interface such as a thin sheet of metal or coin.

5.1.5 *Projectile*—An object which is launched or projected to impact the surface of the examination article. Examples include a steel ball dropped onto the surface, a BB gun fired at the surface or a mass at the end of a pendulum. In most cases the energy being imparted onto the surface can be determined.

5.1.6 *Gas Jet*—A gas jet forces a gas through a nozzle at high pressure onto the surface of the examination article being instrumented. The gas jet is controlled by an electronic valve with the ability of being turned on momentarily to create a transient surface wave or kept on to create a continuous surface wave.

5.1.6.1 The gas jet is usually used in an industrial environment where compressed air or gas is readily available.

5.1.6.2 The gas jet is usually used in places that are inaccessible so that system verification can be carried out remotely from the sensor.

5.1.6.3 The gas jet is a good device for creating a simulated, continuous leak-type, AE signal.

5.1.7 *Electrical Spark Discharge*—A spark struck between two electrodes near the surface of the examination article generates stress waves that propagate in a manner similar to acoustic emission. The technique can be used in a similar manner to a pencil lead break or independent piezoelectric pulser. The advantage of an electrical spark discharge is its short duration and impulse type response, providing a wide-band frequency response.

5.1.8 *Mechanical Cracker*—A mechanically loaded device which is embrittled or subjected to chemical attack (which causes it to crack at a rate controlled by the applied mechanical load). When coupled to the surface of the examination article, the device produces true AE signals of varying amplitude. This method truly generates acoustic emission and is useful in characterizing the AE system response to a brittle crack.

6. Procedure

6.1 The procedure for accomplishing system performance verification utilizes one of the devices listed in Section 5 to produce a stress wave on the examination article. The sensor(s), mounted a specified distance from the verification device detects the stress wave and the acoustic emission system processes the information for display and storage. The operator of the acoustic emission system examines the data to determine if they are within the limits specified in the written test procedure. Note that two operators may be required: one to operate the verification device (for example, PLB) and a second to read the data and record the results.

6.1.1 *Verification of Acoustic Emission transient signal parameters (or AE features)*—Waveform parameters/features that are necessary for achieving the desired examination results are typically required to be measured, within a specified degree of accuracy, during system performance verification. These parameters and the required degree of accuracy are specified in the written test procedure.

6.1.1.1 An example of this process is provided in Table 1 and Fig. 1 where peak amplitude from each sensor is used to verify system performance. The accuracy requirements used in this example are found in Test Method E1419, Table X1.2.

TABLE 1 Example of Peak Amplitude Performance Verification

NOTE 1—Specific values are found in Test Method E1419, Appendix X1. At a specified distance of greater than 4 in. from each sensor a PLB verification device is used. The acoustic emission system must respond with a specified peak amplitude reading of greater than 70 dB_{AE}.

Waveform parameter to be verified	Peak amplitude
Specified acceptable range	> 70 dB_{AE}
Verification device	PLB
Lead diameter	0.3 mm
Lead hardness	2H
Lead length	0.1 in. (2.5 mm)
PLB distance	>4 in., specify

TABLE 2 Example of Source Location Accuracy

NOTE 1—Specific details for system performance verification are found in Test Method E1419, Table X1. With one sensor attached to each end of a tube (examination article) a PLB is performed at specified intervals, in a straight line, between the two sensors. Determination of source location accuracy is made by comparing the AE system results to the actual PLB position as measured with a ruler or tape-measure.

Waveform parameter to be verified	Source location accuracy
Specified acceptable range	Within ±12 in. of ruler measurement
Verification device	PLB
Lead diameter	0.3 mm
Lead hardness	2H
Lead length	0.1 in. (2.5 mm)
PLB to sensor distance	24 inch intervals along tube length

TABLE 3 Example of Steady State Data Acquisition Rate

NOTE 1—Specific details for system performance verification found in Test Method E1419, Table X1.2.

Waveform parameter to be verified	Steady State Data Acquisition Rate (1/Dead Time)
Specified acceptable range	>100 events/sec (1/10 ms)
Verification device	waveform generator with pulser
Pulse width	1 μs
Pulse shape	square wave
Pulse height	10 V
Pulser	150 kHz resonance
Minimum detected amplitude	80 dB_{AE}

6.1.2 *Verification of Source Location Accuracy*—Source location accuracy that is necessary for achieving the desired examination results are typically required to be measured, within a specified degree of accuracy, during system performance verification. The means of determining source location and the required degree of accuracy are specified in the written test procedure.

6.1.2.1 An example of this process is provided in Table 2 and Fig. 2 where linear source location accuracy is measured to verify system performance. The accuracy requirements used in this example are found in Test Method E1419, Table X1.2.

6.1.3 *Verification of System Data Acquisition Rate*—System data acquisition rate performance is influenced by system settings such as threshold and dead time. Generally, the operator would like the threshold and dead-time to be as low as the systems data acquisition rate will allow in order to optimize the test results. To determine if a system has sufficient data rate performance to carry out a particular test procedure the operator attaches sensors to the examination article and uses the verification device at various positions. During this process the dead time setting is lowered until multiple events are observed for a single use of the verification device. In the example which follows Test Method E1419, Table X1.2, this dead-time value is 10 ms. To accommodate a dead-time setting of 10 ms the AE system must have a steady state throughput rate of 100 events/second (10 mseconds/event = 0.01seconds/event, 1/0.01 seconds/event = 100 events/second) To verify that a system is capable of achieving a steady state data rate of