Designation: E 1211 – 97

Standard Practice for Leak Detection and Location Using Surface-Mounted Acoustic Emission Sensors[1]

This standard is issued under the fixed designation E 1211; 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 describes a passive method for detecting and locating the steady state source of gas and liquid leaking out of a pressurized system. The method employs surface-mounted acoustic emission sensors (for noncontact sensors see Test Method E 1002), or sensors attached to the system via acoustic waveguides (for additional information, see Terminology E 1316), and may be used for continuous inservice monitoring and hydrotest monitoring of piping and pressure vessel systems. High sensitivities may be achieved, although the values obtainable depend on sensor spacing, background noise level, system pressure, and type of leak. This practice is not intended to provide a quantitative measure of leak rates.

1.2 The values stated in inch-pound units are to be regarded as the standard. SI units are provided for information only.

1.3 *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:*

E 650 Guide for Mounting Piezoelectric Acoustic Emission Sensors[2]

E 750 Practice for Characterizing Acoustic Emission Instrumentation[2]

E 976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response[2]

E 1002 Test Method for Leaks Using Ultrasonics[2]

E 1316 Terminology for Nondestructive Examinations[2]

2.2 *Other Documents:*

SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel Qualification and Certification[3]

ANSI/ASNT CP-189 ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel[3]

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification[4]

3. Summary of Practice

3.1 This practice requires the use of contact sensors, amplifier electronics, and equipment to measure their output signal levels. The sensors may be mounted before or during the test period and are normally left in place once mounted rather than being moved from point to point.

3.2 Detection of a steady-state leak is based on detection of the continuous, broadband signal generated by the leak flow. Signal detection is accomplished through measurement of some input signal level, such as its root-mean-square (RMS) amplitude.

3.3 The simplest leak test procedure involves *only* detection of leaks, treating each sensor channel individually. A more complex test requires processing the signal levels from two or more sensors together to allow computation of the approximate leak location, based on the principle that the leak signal amplitude decreases as a function of distance from the source.

4. Significance and Use

4.1 Leakage of gas or liquid from a pressurized system, whether through a crack, orifice, seal break, or other opening, may involve turbulent or cavitational flow, which generates acoustic energy in both the external atmosphere and the system pressure boundary. Acoustic energy transmitted through the pressure boundary can be detected at a distance by using a suitable acoustic emission sensor.

4.2 With proper selection of frequency passband, sensitivity to leak signals can be maximized by eliminating background noise. At low frequencies, generally below 100 kHz, it is possible for a leak to excite mechanical resonances within the structure that may enhance the acoustic signals used to detect leakage.

5. Basis of Application

5.1 *Personnel Qualification*—Nondestructive testing (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, MIL STD-410, or a similar document. The practice or standard used and its

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[1] This practice is under the jurisdiction of ASTM Committee E-7 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.04 on Acoustic Emission Method.

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

[3] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, PO Box 28518, Columbus, Ohio 43228-0518.

[4] Available from Standardization Documents Order Desk, Building 4 Section D, 700 Robbins Avenue, Philadelphia, PA 19111-5904, Attn: NPODS.

applicable revision shall be specified in the contractual agreement between the using parties.

5.2 *Qualification of Nondestructive 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. Interferences

6.1 External or internal noise sources can affect the sensitivity of an acoustic emission leak detection system. Examples of interfering noise sources are:

6.1.1 Turbulent flow or cavitation of the internal fluid,

6.1.2 Noise from grinding or machining on the system,

6.1.3 Airborne acoustic noise, in the frequency range of the measuring system,

6.1.4 Metal impacts against, or loose parts frequently striking the pressure boundary, and

6.1.5 Electrical noise pick-up by the sensor channels.

6.2 Stability or constancy of background noise can also affect the maximum allowable sensitivity, since fluctuation in background noise determines the smallest change in level that can be detected.

6.3 The acoustic emission sensors must have stable characteristics over time and as a function of both the monitoring structure and the instrumentation system test parameters, such as temperature.

6.4 Improper sensor mounting, electronic signal conditioner noise, or improper amplifier gain levels can decrease sensitivity.

7. Basic Information

7.1 The following items must be considered in preparation and planning for monitoring:

7.1.1 Known existing leaks and their distance from the areas to be monitored should be noted so that their influence on the capabilities of the method can be evaluated.

7.1.2 Type of vessel, pipeline, or installation to be examined, together with assembly, or layout drawings, or both, giving sufficient detail to establish dimensions, changes of shape likely to affect flow characteristics, positions of welds, and the location of components such as valves or flanges, and attachments to the vessel or pipe such as pipe hangers where leaks are most likely to arise. Regions with restricted accessibility due to walls, the existence or location of cladding, insulation, or below surface components must be specified.

7.1.3 When location of the peak is of primary interest, quantitative information regarding the leakage rates of interest and whenever possible the type of leak is necessary.

7.1.4 Extent of monitoring, for example, entire volume of pressure boundary, weld areas only, etc.

7.1.5 Material specifications and type of surface covering (for example paint or other coating) to allow the acoustic propagation characteristics of the structure to be evaluated.

7.1.6 Proposed program of pressure application or process-pressure schedule, specifying the pressurization schedule together with a layout or sketch of the pressure-application system and specifying the type of fluid used during the test, for example, gas, water, or oil.

7.1.7 Time of monitoring, that is, the point(s) in the manufacturing process, or service life at which the system will be monitored, or both.

7.1.8 Frequency range to be used in the monitoring equipment.

7.1.9 Environmental conditions during examination that may affect instrumentation and interpretation of results; for example, temperature, moisture, radioactivity, vibration, pressure, and electromagnetic interference.

7.1.10 Limitations or restrictions on the sensor mounting procedure, if applicable, including restrictions on couplant materials.

7.1.11 The location of sensors or waveguides and preparation for their installation to provide adequate coverage of the areas specified in 7.1.3. Where particular sections are to be examined with particular sensors, the coverage of the vessel or system by sensor subgroups shall be specified. The sensor locations must be given as soon as possible, to allow positioning difficulties to be identified.

7.1.12 The communications procedure between the acoustic emission staff and the control staff, the time intervals at which pressure readings are to be taken, and the procedure for giving warning of unexpected variations in the pressure system.

7.1.13 Requirements for permanent records, if applicable.

7.1.14 Content and format of test report, if required.

7.1.15 Acoustic Emission Examiner qualifications and certification, if required.

8. Apparatus

8.1 *Sensors*—The acoustic emission sensors are generally piezoelectric devices and should be mounted in accordance with Practice E 650 to ensure proper signal coupling. The frequency range of the sensors may be as high as 1 MHz, and either wideband or resonant sensors may be employed. The higher frequencies can be used to achieve greater discrimination against airborne or mechanical background noise.

8.2 *Amplifiers*—Amplifiers should have sufficient gain to allow the signal processing equipment to detect the level of acoustic background noise on the pressurized system. The sensor/amplifier bandwidth should be selected to minimize background noise.

8.3 *Signal Processor*—The signal processor measures the RMS level, the acoustic emission signal power, the average signal level, or any other similar parameters of the continuous signal. A leak location processor to compute the source location from signal levels and attenuation data may be included. Alarm setpoints may also be included as a processor function.

8.4 *Leak Signal Simulator*:

8.4.1 A device for simulating leaks should be included to evaluate the effectiveness of the monitor system. The following could be considered: a sensor on the pressure boundary driven from a random noise generator, a small water jet, or a gas jet.

8.4.2 When leak location processing is to be performed, leak simulation should be carried out initially over a sufficiently large number of diverse points to verify proper operation of the location algorithm.