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Standard Guide for Acoustic Emission Examination of Small Parts[1]

This standard is issued under the fixed designation E 1932; 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.

ϵ^1 NOTE—Editorially replaced the term "test" with "examination" wherever appropriate in July 2002. Also, there were miscellaneous editorial corrections made throughout the standard in July 2002.

1. Scope

1.1 This guide covers techniques for conducting acoustic emission (AE) examinations of small parts. It is confined to examination objects (or defined regions of larger objects) where there is low AE signal attenuation throughout the examination region. This eliminates the consideration of complex attenuation factor corrections and multiple sensor and array placements based on overcoming signal losses over distances.

1.2 The guide assumes a typical AE examination as one where there is a controlled or measured stress acting upon the part being monitored by AE. Particular emphasis is placed on sensor and system selection, sensor placements, stressing considerations, noise reduction/rejection techniques, spatial filtering, location determination, use of guard sensors, collection of AE data, AE data analysis and report. The purpose of the AE examination is to analyze how an object under evaluation is withstanding the applied load.

1.3 Possible applications of this guide includes materials characterization, quality control of production processes, proof testing after fabrication, evaluating regions of interest of larger structures and retesting after intervals of service. The applied load may include mechanical forces (tension, compression or torsional) internal pressure and thermal gradients.

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.*

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 1316 Terminology For Nondestructive Examinations[2]

3. Terminology

3.1 *Definitions*:

3.1.1 Terminology related to acoustic emission is defined in Terminology E 1316.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *applied load*—a controlled or known force or stress which is applied to an object under examination for the purpose of analyzing the object's reaction (by means of AE monitoring) to that stress.

3.2.2 *guard sensors*—sensors whose primary function is the elimination of extraneous noise based on arrival sequences.

3.2.3 *spatial discrimination*—the process of using one or more (guard and data) sensors to eliminate extraneous noise based on arrival sequences.

3.2.4 *spatial filtering*—ability of an AE system or analysis to disregard AE activity based on source location of the AE event.

4. Significance and Use

4.1 The purpose of the AE examination is to analyze how an examination object is withstanding the applied load, or if it is suffering from some latent damage. Consequently the emission activity must be evaluated in relation to the applied load.

4.2 The applied load (on the examination object) may include mechanical forces (tension, compression or torsional), internal pressure and thermal gradients. It may be short to long, random or cyclic. The applied load may be controlled by the examiner or may already exist as part of the process. In either case the applied load is measured along with the AE activity.

4.3 Possible applications are determination of part integrity, quality control assessment of production processes on a sampled or 100 % inspection basis, in-process examination during a period of applied load of a fabrication process (for example, spot welding, bonding, soldering, pressing, etc.), proof-testing after fabrication, monitoring a "region of interest" (or concern) of a structure (for example, bridge joint or repair, vessel, pipe), and re–examination after intervals of service.

[1] This guide 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] *Annual Book of ASTM Standards*,Vol 03.03.

5. Procedure

5.1 *Preliminary Information*:

5.1.1 Before examination, the following information, where relevant, should be obtained by the AE examiner:

5.1.1.1 Type of object to be examined, together with layout drawings or sketches.

5.1.1.2 Material specifications (including details of heat treatment where possible).

5.1.1.3 Proposed or existing applied load specification together with a layout or sketch of the pressure/stress application system.

5.1.1.4 Information regarding the measuring or recording of the applied load must also be obtained in order to determine the compatibility with the AE equipment.

5.1.1.5 Potential sources of background noise and the isolating mechanisms applied thereto.

5.1.1.6 Previous history, including the maximum applied load to which the object or system has been subjected.

5.1.1.7 Where possible, locations of known discontinuities and the general results of earlier AE or other NDE.

5.1.1.8 Results of earlier examinations on similar objects.

5.1.2 Before examination, the AE examiner should consider the following information. Some details need to be coordinated with the on-site management or responsible personnel:

5.1.2.1 *The Type of AE Equipment to be Used*—Considerations should include the number of channels, the frequency range of the instrument's filters, the real-time data processing rates for the type of application, its location/guard/spatial filtering capabilities, the type of data being collected (for example, RMS, ASL, AE feature based or waveform based) and the compatibility of the system to monitor and record the applied load during the AE examination. These items must be able to perform at the anticipated levels of performance expected during the examination. In addition, consideration should be given to the data analysis, display and replay capabilities of the equipment to assure its ability to process the stored data in a way needed to arrive at a satisfactory conclusion and examination result.

5.1.2.2 *Application of Load*—Consideration should be given to the application of the load in relation to the integrity of the examination object and achieving a successful AE examination result. In cases where the applied load is part of the process being monitored, a suitable time for AE monitoring needs to be determined where process noise is low and applied load (for AE examination purposes) maximum. Sometimes (if needed) the applied loading can be altered to achieve this without compromising the process (for example, inserting a short load hold at maximum load).

(1) In cases where the applied load is controlled with the examination, then consideration should be given to design the loading schedule to appropriately stress the examination object in order to excite "latent flaws" without over-stressing or damaging the object. In addition, the loading schedule should be designed to provide best insight into the integrity of the part (for example, implementing a load schedule to evaluate the "Kaiser effect").

5.1.2.3 *Sensor Types*—Considerations that should guide the user into proper selection include the sensor's frequency range, size (including sensor height, diameter and weight), maximum or minimum temperature specification, the sensor's sensitivity and frequency response, and acoustic impedance matching of the sensor and part.

5.1.2.4 *Location of Sensors and Placement Strategy*—Considerations need to be given to the number of sensors required for the examination, their placement strategy and location on the part to be monitored.

(1) In cases where background noise can be controlled or does not exist, then a single sensor near the expected source of the AE is sufficient.

(2) In cases where there are a limited number of background noise sources (such as the grips in a tension test), a single AE data sensor near the expected source of AE and the use of a guard sensor near each background source will effectively block noises that emanate from a region closer to the guard sensors than to the AE data sensor. Alternatively, a group of two or more sensors can be strategically placed to perform spatial discrimination of background noise and allow processing of AE events.

(3) In cases where extraneous noise cannot be controlled and could be emanating from any or all directions, a multiple-sensor location strategy (such as linear or planar location) should be considered. In this situation, enough sensors should be specified to allow for an accurate source location, and means should be available to allow for the application of spatial filtering and/or spatial discrimination so that only data emanating from the region of interest is processed as relevant AE data.

5.1.2.5 *Data to be Recorded*—The AE examiner should know in advance the data and information to be recorded and have all the necessary equipment, hardware, accessories and software to acquire, store, and process this information. Other than the equipment for AE monitoring, appropriate sensors and devices are required for measuring and recording the applied load and other load or condition related parametric data. Details of any interfaces may need to be coordinated with the examination site management and personnel.

5.1.2.6 Applicability and possible limitations of the method for the particular examination.

5.1.2.7 Any preconditions necessary for conducting the AE examination such as surface preparation or limitation of pressurization rate needs to be coordinated with the examination-site management or responsible personnel.

5.2 *Sensor Installation*—The methods and procedures used in mounting AE sensors can have significant effects upon the performance of those sensors. Optimum and reproducible detection of AE requires both appropriate sensor-mounting fixtures and consistent sensor-mounting procedures. Refer to Guide E 650.

5.3 *Calibration and Verification*:

5.3.1 Annual calibration and verification of pressure transducer, AE sensors, preamplifiers (if applicable), signal processor (particularly the signal processor time reference), and AE electronic simulator (waveform generator) should be performed. Equipment should be adjusted so that it conforms to the equipment manufacturer's specifications. Instruments used for calibrations must have current accuracy certification that is traceable to the National Institute for Standards and Technology (NIST).

5.3.2 Routine electronic evaluations should be performed any time there is concern about signal processor performance. An AE electronic simulator (waveform generator) should be used in making evaluations. Each signal processor channel must respond with peak amplitude reading within ±2 dBV of the electronic waveform generator output. Guide E 750 describes other measurements for characterizing AE equipment.

5.3.3 A system performance check should be conducted immediately before, and immediately after, each AE examination. A performance check uses a mechanical device to induce stress waves into the examination object at a specified distance from each sensor. Induced stress waves stimulate a sensor in a manner similar to the emission from a flaw. Performance checks verify performance of the entire system (including couplant).

5.3.3.1 The preferred technique for conducting a performance check is a pencil lead break. Lead should be broken on the examination object surface at a prescribed distance from the sensor. 2H lead, 0.3mm or 0.5 mm diameter, 2.5 mm long should be used (see 4.3.3 in Guide E 976). In establishing the details of the lead break technique, care should be taken to avoid saturating the electronics.

5.4 *Examination*:

5.4.1 *Pre-Examination Requirements*—Before the AE examination, the following requirements should be completed.

5.4.1.1 Visually examine the examination object, the acoustic sensors and other instrumentation, to verify that the equipment is securely mounted and isolated from controllable sources of acoustic and electrical noise.

5.4.1.2 Review the examination object to identify all potential sources of background noise such as rubbing surfaces (friction), pump or other vibration, valve stroking, personnel movement, fluid flow and turbulence. Evaluate background noise by monitoring the AE for a short period without the applied load or under slight loading conditions (if possible). Identified sources may require acoustic isolation or control, so that they will not mask relevant acoustic emission sources within the object being examined.

5.4.1.3 Test spatial filtering, or other applied discrimination facilities, to prove its/their capability to reject extraneous burst-type noise.

5.4.2 *Collection of AE Data*:

5.4.2.1 Begin monitoring and recording AE data and subject the examination object to the applied load.

5.4.2.2 During AE examination, whenever circumstances allow, the noise at each sensor should be monitored periodically to ensure that background noise remains acceptable for continued AE examination. The magnitude of the noise, the times of any specific noise incidents and the effect of the noise on the AE examination, shall be recorded.

5.4.2.3 The applied load or other parameters, or both, should be monitored and recorded to the extent necessary to allow correlation with the AE data.

5.4.2.4 Acoustic emission data should be collected continuously during load applications as well as during holds and unloading.

5.5 *Data Analysis*—The AE signals should be analyzed to determine the integrity of examination objects after loading. This analysis should be made over ranges of a relevant parameters such as pressure (applied load), time, stress and temperature. If location or spatial filtering facilities are used, only AE signals which were generated within the region of interest should be analyzed.

5.5.1 *Emission Activity*—AE activity of the part(s) being examined may be determined as the cumulative AE or event count, or derived from parameters of detected 0AE signals or otherwise. The analysis techniques should be uniform and repeatable.

5.5.2 *Evaluation Criteria*—Evaluating the emission activity of actual examination objects is based on criteria which have been derived from previous similar examinations. Consideration of the statistical variance in data is necessary as with all acceptance criteria. Particular attention should be paid to the time dependence of the emission activity during load holds. The examiner should specify the criteria adopted.

5.5.3 *Kaiser Effect*—Evaluation should consider an analysis of the examination objects integrity based on its adherence to the Kaiser effect (see Terminology E 1316)

5.6 *Records*—Records of the results and their interpretation should include:

5.6.1 *Preliminary Information*:

5.6.1.1 The acoustic emission system and its characteristics (for example, criteria for AE signal recognition, channel dead-time, frequency filter values, gain, system threshold, data processing rate or measures of activity),

5.6.1.2 Identity and qualifications of examination personnel,

5.6.1.3 Date and time of examination,

5.6.1.4 Part description and identification,

5.6.1.5 Method of coupling sensors to object,

5.6.1.6 Position of sensors, and

5.6.1.7 Surface condition of the part examined (for example, bright finish, dull oxide, painted).

5.6.2 *Calibration Records*—In addition to detailing the method of measurement and the results of the measurements, the examiner should include:

5.6.2.1 The type and characteristics of artificial sources used,

5.6.2.2 The sensitivities of the sensor channels,

5.6.2.3 The AE signal attenuation, and

5.6.2.4 The efficiency of spatial filtering, spatial discrimination, if applied.

5.6.3 *Examination Records*—should include:

5.6.3.1 The background noise and its variation,

5.6.3.2 Changes in characteristics of the AE system during the examination,

5.6.3.3 Presentation of AE activity (by parametric interval, if relevant), and

5.6.3.4 Actual loading history of examination (if relevant).

6. Report

6.1 On completion of the examination and any post-examination analysis of data that may prove necessary, all results should be summarized in figures and tables. The evaluation criteria adopted and their experimental basis should also be described. The result concerning the integrity of the actual examination object(s) should be discussed, with careful evaluation of all factors influencing the evidence from the measurements.

6.2 The examiner should submit a signed report of the examination, that includes the records cited in 5.6 and the summary (see 6.1).

7. Keywords

7.1 acoustic emission; materials characterization; nondestructive evaluation; nondestructive testing; production quality control; small parts

APPENDIX

(Nonmandatory Information)

X1. EXAMPLE OF THE TYPE OF INFORMATION REQUIRED IN ACCORDANCE WITH PARAGRAPH 5.6:

Sensor: (For each sensor, record)

Manufacturer, Model #, S/N's	__________
Temperature range:	From: _____to_____°C
Last Sensor Response Check Date:	__________
Means used to check sensor:	__________

Preamplifier: (For each preamp, record)

Manufacturer, Model #, S/N's	__________
Last Calibration Date:	__________
Gain used (in passband):	__________dB
Output voltage (peak to peak):	__________V_{pp}(into 50Ω)
Filter used (frequency range):	From: _____to_____kHz

AE Instrument:

Manufacturer Name, Model #, S/N:	__________
Last Calibration Date:	__________
Gain used:	__________dB (list for each channel used)
Threshold used (Referred to sensor output):	__________dB (list for each channel used)
Filter used (frequency range):	From: _____to_____kHz
Response (to Artificial Source):	__________dB (list peak amplitude each channel)
Artificial Source used:	__________

External Load Monitoring:

Loading Type Applied (describe):	__________ (If more than one type list them)
Measurement Transducer Used:	
Manufacturer or description:	__________
Measurement Units:	__________
Measurement Range:	From: _____to_____
Conversion Scaling to volts:	__________
Previous load history:	__________

FIG. X1.1 Example of the Type of Information Required