Designation: E650/E650M – 17

Standard Guide for Mounting Piezoelectric Acoustic Emission Sensors[1]

This standard is issued under the fixed designation E650/E650M; 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 document provides guidelines for mounting piezoelectric acoustic emission (AE) sensors.

1.2 *Units*—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.

1.3 *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.*

1.4 *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]

E976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response

E1316 Terminology for Nondestructive Examinations

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *bonding agent*—a couplant that physically attaches the sensor to the structure.

3.1.2 *couplant*—a material used at the structure-to-sensor interface to improve the transfer of acoustic energy across the interface.

3.1.3 *mounting fixture*—a device that holds the sensor in place on the structure to be monitored.

3.1.4 *sensor*—a detection device that transforms the particle motion produced by an elastic wave into an electrical signal.

3.1.5 *waveguide, acoustic*—a device that couples acoustic energy from a structure to a remotely mounted sensor. For example, a solid wire or rod, coupled to a sensor at one end and to the structure at the other.

3.2 *Definitions:*

3.2.1 For definitions of additional terms relating to acoustic emission, refer to Terminology E1316.

4. Significance and Use

4.1 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.

5. Mounting Methods

5.1 The purpose of the mounting method is to hold the sensor in a fixed position on a structure and to ensure that the acoustic coupling between the sensor and the structure is both adequate and constant. Mounting methods will generally fall into one of the following categories:

5.1.1 *Compression Mounts*—The compression mount holds the sensor in intimate contact with the surface of the structure through the use of force. This force is generally supplied by springs, torqued-screw threads, magnets, tape, or elastic bands. The use of a couplant is strongly advised with a compression mount to maximize the transmission of acoustic energy through the sensor-structure interface.

5.1.2 *Bonding*—The sensor may be attached directly to the structure with a suitable adhesive. In this method, the adhesive acts as the couplant. The adhesive must be compatible with the structure, the sensor, the environment, and the examination procedure.

6. Mounting Requirements

6.1 *Sensor Selection*—The correct sensors should be chosen to optimally accomplish the AE examination objective. Selection parameters to be considered are as follows: size,

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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.

*A Summary of Changes section appears at the end of this standard sensitivity, frequency response, surface-motion response, environmental compatibility, background noise, source location requirements, and material properties of the structure under examination. When a multichannel acoustic-emission examination is being conducted, a subset of sensors with characteristics similar to each other should be selected. See Guide E976 for methods of comparing sensor characteristics.

6.1.1 If the examination objective is to include AE source location, sensor selection may be governed by the material properties of the structure and may affect subsequent sensor spacing due to attenuation. It may be necessary to evaluate attenuation effects as part of the pre-examination procedure. If performed, the attenuation data shall be retained as part of the experimental record.

6.1.2 When a multichannel acoustic-emission examination is being conducted, a subset of sensors with characteristics similar to each other should be selected. See Guide E976 for methods of comparing sensor characteristics.

6.2 *Structure Preparation*—The contacting surfaces should be cleaned and mechanically prepared. This will enhance the detection of the desired acoustic waves by assuring reliable coupling of the acoustic energy from the structure to the sensor. Preparation of these surfaces must be compatible with the construction materials used in both the sensor and the structure. Possible losses in acoustic energy transmission caused by coatings such as paint, encapsulants, loose-mill scale, weld spatter, and oxides as well as losses due to surface curvature at the contact area must be considered.

6.2.1 The location of each sensor should be measured and marked accordingly on the structure and recorded as part of the examination record.

6.2.2 If surface preparation requires removing paint from a metal surface, the paint may be removed with a grinder or other mechanical means, down to bare metal. The area of paint removal should be slightly larger than the diameter of the sensor. If the metal surface is smooth, sandpaper may be used to roughen the surface prior to bonding.

6.2.2.1 After paint removal, the surface should be cleaned with a degreaser and wiped clean with a cloth.

6.2.2.2 If corrosion is present on the structure, additional cleaning may include using a conditioner (mild acid) and neutralizer to minimize potential corrosion beneath the sensor after mounting.

6.2.2.3 If the structure is located in a marine environment, soluble salts (e.g. chlorides, nitrates, sulfates) may still reside on the steel surface even after cleaning. These types of salts attract moisture from the air, and may result in additional corrosion beneath the sensor and failure of the bond. As such, a liquid soluble salt remover is recommended as an additional step in surface preparation prior to sensor mounting.

6.3 *Couplant or Bonding Agent Selection:*

6.3.1 The type of couplant or bonding agent should be selected with appropriate consideration for the effects of the environment (for example, temperature, pressure, composition of gas, or liquid environment) on the couplant and the constraints of the application. It should be chemically compatible with the structure and not be a possible cause of corrosion. In some cases, it may be a requirement that the couplant be completely removable from the surface after examination. In general, the selection of the couplant is as important from an environmental standpoint as it is from the acoustical standpoint.

6.3.2 For sensors that are primarily sensitive to particle motion perpendicular to their face, the viscosity of the couplant is not an important factor. Most liquids or greases will work as a couplant if they wet the surfaces of both the structure and the sensor. For those few sensors which are sensitive primarily to motion in the plane of their face, very high-viscosity couplant or a rigid bond is recommended.

6.3.2.1 Testing has shown that in most cases, when working at frequencies below 500 kHz, most couplants will suffice. However, due to potential loss of high frequency (HF) spectra when working above 500 kHz, a low viscosity couplant or rigid bond, relative to sensor motion response, is recommended. Additionally, when spectral response above 500 kHz is needed, it is recommended that FFT be performed to verify adequacy of HF response.

6.3.3 The thickness of the couplant may alter the effective sensitivity of the sensor. The thinnest practical layer of continuous couplant is usually the best. Care should be taken that there are no entrapped voids in the couplant. Unevenness, such as a taper from one side of the sensor to the other, can also reduce sensitivity or produce an unwanted directionality in the sensor response.

6.3.4 A useful method for applying a couplant is to place a small amount of the material in the center of the sensor face, then carefully press the sensor on to the structure surface, spreading the couplant uniformly from the center to the outside of the sensor face. Typically, this will result in a small band (fillet) of couplant around the outside circumference of the sensor.

6.3.5 In some applications, it may be impractical to use a couplant because of the nature of the environment (for example, very high temperatures or extreme cleanliness requirements). In these situations, a dry contact may be used, provided sufficient mechanical force is applied to hold the sensor against the structure. The necessary contact pressure must be determined experimentally. As a rough guide, this pressure should exceed 0.7 MPa [100 psi].

6.3.6 Great care must be taken when bonding a sensor to a structure. Surface deformation, that can be produced by either mechanical loading or thermal expansion, may cause a bond to crack, peel off, or, occasionally, destroy the sensor. Bond cracking is a source of acoustic emission. A pliant adhesive may work in some cases. If differential expansion between the sensor, the bond, and the surface is a possibility, a suitable bonding agent should be confirmed by experiment.

6.3.7 When bonding agent are used, the possibility of damaging either the sensor or the surface of the structure during sensor removal must be considered.

6.3.7.1 To minimize damage to the sensor during removal, any excess bonding agent may be gently removed from around the base of the sensor using a small chisel and hammer or mallet. Place a small block of wood, or the handle of the chisel, at the base of the sensor. Using a hammer or mallet gently tap the side of the block or handle to generate a shear force at the base of the sensor to break the bond. Attempting to pry or twist off the sensor by hand, or striking the side of the sensor at the top will often cause the ceramic face or wear plate of the sensor to debond from the sensor housing and destroy the sensor.

6.3.7.2 Any bonding agent remaining on the face of the sensor after removal may be gently chipped off or removed with a grinder at low speed to avoid damage to the wear plate.

6.3.8 The use of double-sided adhesive tape as a bonding agent is not recommended.

6.4 *Mounting Fixture Selection:*

6.4.1 Mounting fixtures must be constructed so that they do not create extraneous acoustic emission or mask valid acoustic emission generated in the structure being monitored.

6.4.1.1 The mount must not contain any loose parts of particles.

6.4.1.2 Permanent mounting may require special techniques to prevent sensor movement caused by environmental changes.

6.4.1.3 Detection of surface waves may be suppressed if the sensor is enclosed by a welded-on fixture or located at the bottom of a threaded hole. The mounting fixture should always be designed so that it does not block out a significant amount of acoustic energy from any direction of interest.

6.4.2 The mounting fixture should provide support for the signal cable to prevent the cable from stressing the sensor or the electrical connectors. In the absence of a mounting fixture, some form of cable support should be provided. Care should be taken to ensure that the cable can neither vibrate nor be moved easily. False signals may be generated by the cable striking the structure and by triboelectric effects produced by cable movement.

6.4.3 Where necessary, protection from the environment, such as encapsulation, should be provided for the sensor or sensor and mounting fixture.

6.4.4 The mounting fixture should not affect the integrity of the structure being monitored.

6.4.4.1 Permanently installed mounting fixtures must be constructed of a material compatible with the structure. Possible electrolytic effects or other forms of corrosion must be considered when designing the mounting fixture.

6.4.4.2 Alterations of the local environment by the mount, such as removal of the insulation, must be carefully evaluated and corrected if necessary.

6.4.5 The mounting fixture should be designed to have a minimal effect on the response characteristics of the sensor.

6.4.6 Mounting fixtures and waveguides should be designed to provide isolation of the sensor case from the fixture or waveguide that is in contact with the structure to avoid grounding the sensor to the structure ground, especially those sensors that use an isolated sensor face (e.g epoxy or ceramic face). Failure to isolate the sensor will result in a ground loop and will create a significant amount of electrical noise in the AE system and may mask detection of the AE activity of interest.

6.5 *Waveguides*—When adverse environments make direct contact between the sensor and the structure undesirable, an acoustic waveguide may be used to transmit the acoustic signal from the structure to the sensor. The use of a waveguide adds another boundary transition with its associated losses between the structure and the sensor, and will distort, to some degree, the characteristics of the acoustic wave.

6.5.1 An acoustic waveguide should be mounted to ensure that its surface will not contact any materials that will cause signal damping in the waveguide.

6.5.2 If acoustic waveguides are used when acoustic-emission source location is being performed, the extra time delay in the waveguides must be accounted for in the source location program.

7. Verification of Response

7.1 After the sensor(s) are mounted on a structure, adequate response should be verified by injecting acoustic signals into the structure and examining the detected signal either on an oscilloscope or with the AE system to be used in the examination. If there is any doubt as to the sensor response, the sensor should be remounted.

7.1.1 The test signal may be injected by an external source such as the Hsu-pencil source, or a gas jet (helium or other suitable gas), or by applying an electrical pulse to another sensor mounted on the structure. For a description of these methods see Guide E976.

7.2 *Periodic Verification*—On an extended acoustic emission examination, it may be desirable to verify the response of the sensors during the examination. Verification should be performed whenever circumstances indicate the possibility of a change in the coupling efficiency.

7.3 *Post Verification*—At the end of an acoustic emission examination, it is good practice to verify that all sensors are still working and that there have been no dramatic changes in coupling efficiencies.

8. Report

8.1 Any report of the mounting practice should include details of the sensor mounting fixture(s), surface preparation method, and the couplant that was used.

9. Keywords

9.1 acoustic emission; acoustic emission sensors; acoustic emission transducers; AE; bonding agent; couplant; mounting fixture; waveguide

SUMMARY OF CHANGES

Committee E07 has identified the location of selected changes to this standard since the last issue (E650 - 12) that may impact the use of this standard. (June 1, 2017)

(1) Added additional considerations for sensor selection to 6.1.
(2) New section, 6.1.1, regarding selection of sensors for use in source location added.
(3) Moved last 2 sentences from 6.1 to 6.1.2.
(4) Added additional steps in 6.2.1 to 6.2.2.3 for surface preparation, particularly for steels with corrosion present on the structure and/or structures located in a marine environment.
(5) New section 6.3.2.1 added, regarding couplant recommendations when working below or above 500 kHz.
(6) In 6.3.6, changed word from "compliant" to "pliant." "Compliant" term is more for "in accordance to," whereas "plaint" means "flexible or adaptable."
(7) In 6.3.7, changed "bonds" to "bonding agents" for clarity.
(8) Added steps in 6.3.7.1 to 6.3.7.2 for removal of sensors and excess bonding agent to minimize damage to sensor.
(9) Added fixture and waveguide design consideration for isolating sensor from each apparatus to prevent ground loop with structure to 6.4.6.
(10) In 6.5, changed "inserts another interface" to "adds another boundary condition" for clarity, added comma.
(11) In 6.5.1, removed "so as" for clarity.