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MILITARY STANDARDIZATION HANDBOOK

FIELD ASSURANCE OF ACOUSTIC EMISSION SYSTEM OPERATION USING SIMULATED ACOUSTIC EMISSION EVENTS

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FIELD ASSURANCE OF ACOUSTIC EMISSION SYSTEM OPERATION
USING SIMULATED ACOUSTIC EMISSION EVENTS

1. This standardization handbook was developed by the Department of Defense with the assistance of the U.S Army Materials Technology Laboratory and under a contract with Physical Acoustics Corporation. It is approved for use by all departments and agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Director, US Army Laboratory Command, Materials Technology Laboratory, ATTN: SLCMT-MSE, Watertown, MA 02172-0001 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

FOREWORD

The use of acoustic emission testing and monitoring is growing rapidly. Because acoustic emission testing is carried out with complex, often computerized, electronic equipment it is important to verify the proper functioning and setup of the equipment during a field test. This handbook has been developed to assist Department of Defense Personnel in determining that the acoustic emission equipment functions properly upon arrival at the field test site, that the sensors are coupled efficiently to the test structure, that neither the acoustic emission system or the sensors underwent a performance degradation during the test, and that similar sensitivity levels exist between channels prior to the start of the test.

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FIGURES

1. SCOPE

1.1 Purpose. This handbook provides a procedure for assuring the proper operation of an acoustic emission system installed on a field test article. This handbook allows the user:

1. to insure that no degradation of performance has occurred from the laboratory sensor/system calibration upon arrival at the test site;

2. to check for proper sensor installation and coupling to the test article before the test;

3. to provide a method for adjusting all system channels to similar sensitivity levels prior to testing; and

4. to detect any performance changes during the test due to electronic malfunctions or sensor coupling problems.

1.2 Method. This handbook relies on the Hsu Pencil Source to provide repeatable simulated acoustic emission events. Full details on the procedure to be followed for the proper use of the Hsu Pencil Source are embodied in 3.2 of this handbook.

1.3 Terminology. Definitions for many terms used in this handbook are contained in MIL-STD-1945.

2. REFERENCED DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this handbook to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto, cited in the solicitation.

STANDARDS

MILITARY

MIL-STD-1945 - Glossary of Terms and Definitions for Acoustic Emission Testing Procedures

(Copies of specifications, standards, handbooks, drawings, publications, and other Government documents required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Other publications. The following document(s) form a part of this handbook to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted shall be those listed in the issue of the DODISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS shall be the issue of the non-government documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM E650 - Mounting Piezoelectric Acoustic Emission Contact Sensors
ASTM E750 - Standard Practice for Measuring the Operating Characteristics of Acoustic Emission Instrumentation
ASTM E976 - Guide for Determining the Reproducibility of Acoustic Emission Sensor Response
ASTM E1106 - Primary Calibration of Acoustic Emission Sensors

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

3. VERIFICATION PROCEDURE

3.1 Mounting of sensors. Sensors should be mounted as prescribed in the testing procedure. In the absence of specific mounting instructions, the guidelines described in ASTM E650 should be followed. The following are important considerations in the mounting of acoustic emission sensors.

3.1.1 Mounting method. The mounting method has the purpose of holding the sensor on the structure in a fixed position and ensuring that the acoustic coupling between the sensor and the structure is adequate and constant. Compressional methods (using springs, torqued-screw threads, magnets, tape, or elastic bands) in conjunction with an acoustic couplant are one means of mounting sensors. Bonding (using a suitable adhesive which acts as a couplant) forms another means.

3.1.2 Structure preparation. Contacting surfaces should be cleaned and mechanically prepared in a manner compatible with the materials of the structure and the sensor. Possible losses in acoustic energy transmission caused by paint, encapsulants, loose mill scale, weld spatter, oxides, and surface curvature at the sensor/structure contact area must be considered.

3.1.3 Couplant/bonding agent selection. The couplant/bonding agent selection has both environmental and acoustic aspects. From the environmental standpoint the couplant should be chemically compatible with the sensor and structure, should not cause corrosion, should be removable from the surface after testing, and should be stable with respect to the temperatures, pressures, gases or liquids, and surface deformations present during the acoustic emission test. From an acoustic standpoint the couplant must wet the surfaces of both the sensor and the structure, and should have suitable viscosity for transmitting the type of wave motion of interest. Ideally, the acoustic impedance (defined as the density of the material times the wave speed in the material) of the couplant should be halfway between the acoustic impedance of the structure and the acoustic impedance of the wearplate of the sensor. Typical couplant/bonding agents include silicon vacuum grease and epoxy glue. Double-sided adhesive tape is not recommended.

3.1.4 Couplant/bonding agent application. The effective sensitivity of the sensor can be adversely changed if too thick a couplant layer is used, if voids exist in the couplant, or if the couplant layer is tapered. A useful method for applying couplant is to place a small amount in the center of the sensor face, then carefully press the sensor onto the structure surface, spreading the couplant uniformly from the center to the outside of the sensor face.

3.1.5 Sensor spacing consideration. Materials attenuate acoustic waves. If sensors are too far apart it is possible that acoustic emission events of significance will not be detected.

3.2 Generating acoustic emission. Many different methods of generating simulated acoustic emission events exist. Repeatable acoustic emission events will be generated for the purpose of this handbook using the Hsu pencil source.

3.2.1 Pencil requirements. The Hsu pencil source consists of a mechanical pencil using 0.5 mm or 0.3 mm diameter 2H hardness lead. (Pencils and lead manufactured by Pentel or its equivalent have been found satisfactory for this purpose). The pencil must be equipped with a Nielsen guide ring, shown in Figure 1, to ensure consistent lead breakage. The use of 0.5 mm diameter lead is recommended but 0.3 mm diameter lead may be used instead if an oscilloscope record shows saturation of the system electronics has occurred when the lead is broken on the face of the sensor. Whichever diameter lead is chosen, it must be used consistently during both the laboratory and field procedures described in 3.3.1 through 3.3.3.

3.2.2 Lead length. The lead is extended between 2 and 3 mm from the end of the Hsu pencil source, as shown in Figure 1. After some experimentation, it will be found that a specific number of "clicks" of the pencil will produce a consistent and proper lead length.

3.2.3 Breaking of pencil lead. The Hsu pencil source must be placed on the surface of the structure, resting on the end of the lead and the flange of the Nielsen guide ring, as shown in Figure 1 and in ASTM E976. The Hsu pencil source must be held such that the lead touches an imaginary line drawn between the sensor under test and the Nielsen guide ring surface contact point, with the lead lying between the sensor and the Nielsen guide ring. Gently tilt the Hsu pencil source upwards, pivoting on the Nielsen guide ring, until the lead breaks. Care should be taken so that the tip of Nielsen guide ring does not hit the structure surface, nor that the contact point of the Nielsen guide ring scrapes along the structure surface.

3.2.4 Technique verification. The use of the Hsu pencil source should be practiced on the face of a sensor until it is possible to obtain repeatable acoustic emission events. Tolerances for repeatability among 10 lead breaks are:

Amplitude - Within ± 3 dB from average value
Counts - Within ± 5% from average value

(Note that not all acoustic emission systems measure both amplitude and counts. This handbook covers systems that only measure counts, as well as with systems that measure counts, amplitude, and other acoustic emission parameters).

3.3 System operation verification. This handbook contains procedures to verify that an acoustic emission system (including sensors) is capable of collecting proper acoustic emission data on a field test article. Calibration of the acoustic emission system and the sensors should be performed in the laboratory following the procedures given in ASTM E 750 and ASTM E1106.

3.3.1 Detecting performance degradation A record should be made of the average response value of each acoustic emission parameter measurable for each sensor/system channel when 3 lead breaks are made on the face of each sensor, following the techniques given in 3.2. Call these values Plax and Plcx, where a represents amplitude, c represents counts, and x is the channel number. After the system and sensors are transported to the field test site, the average response value of each acoustic emission parameter measurable for each sensor/system channel to 3 lead breaks on the face of the sensor should be determined. Call these values Pfax and Pfcx, where a represents amplitude, c represents counts, and x is the channel number. If, for a given channel x, the absolute value of Plax - Pfax is greater than 3 dB, and the absolute value of Plcx - Pfcx is greater than 5% of Plcx, then system performance degradation has occurred in that sensor/system channel. The same check for performance degradation may be done again after the conclusion of the field test, if necessary - see 3.3.2.

3.3.2 Verifying sensor coupling. After the sensors have been mounted on the field test article, and again prior to the removal of the sensors after the test, the acoustic coupling should be checked. To check the acoustic coupling, make 9 lead breaks at each sensor following the techniques given in 3.2 - 3 breaks at 3 positions located 120 degrees apart on a circle centered on the sensor. The radius of the circle should ideally be 25% of the distance between sensors, but can be any arbitrary radius provided that it is constant for all sensors and is at least two sensor diameters in length. For each sensor location, calculate the average amplitude value (or average count value if amplitude is not available) for the 9 lead breaks. Call this value Sfax or Sfcx, where a represents amplitude, c represents counts, and x is the channel number. Then calculate Pfax - Sfax (or Pfcx - Sfcx if amplitude is not available) for each sensor/system channel. Call these values Dx, where x is the channel number. Finally, calculate an average difference value by averaging all of the Dx values. Call this value Dave. At the beginning of the test, any sensor where the absolute value for Dave - Dx is greater than 3 dB (or 5% of Dave when counts have been used) should be removed and mounted again. At the end of the test (be sure to restore channel threshold settings to their original values if they are changed after the pre-test sensor coupling check following the procedures of 3.3.3) deviations for any sensor greater than the tolerance just quoted indicate that either the acoustic coupling or system performance changed during the course of the test. The exact cause can be determined by conducting a post-test system performance degradation test, using the procedure outlined in 3.3.1.

3.3.3 Adjusting channel sensitivity. Before changing any channel threshold values, make a record of their original settings, i.e., those existing at the time that the sensor coupling check of 3.3.2 is performed prior to the start of the test. Call these values Tx, where x is the channel number. Most acoustic emission systems allow the user to adjust both threshold and gain to control the overall system sensitivity, however, individual channel thresholds should be adjusted on an "as necessary" basis. This permits the exact test procedure specified gain to be used, and effectively means that the <u>average</u> test procedure specified threshold will be used. To perform channel sensitivity adjustment, repeat the procedure outlined in 3.3.2 several times, but use <u>only</u> the count parameter (even if the system <u>can</u> perform amplitude measurements). At the end of each repetition of the procedure, adjust individual channel thresholds as needed to make Dave - Dx = 0. [Note - Under <u>no</u> circumstances should individual channel thresholds be changed more than 3 dB (a factor of 1.41 upwards and 0.71 downwards if thresholds are measured in volts) from their original settings of Tx - return all thresholds to Tx and abandon the procedures of this paragraph if more change is necessary.] Channel sensitivities are truly identical when all channels have Dx count values equal to Dave, but it will usually be necessary to compromise somewhat and consider channels identical when a Dx count value is within 1% of Dave. Remember to return each channel's threshold to its original value of Tx following the conclusion of the acoustic emission test, so as to obtain valid measurements for the post-test sensor coupling check as described in 3.3.2.

4. NOTES

4.1 Subject term (key word) listing.

Acoustic Emission
Field Calibration of Acoustic Emission Systems

Custodians
Army - MR
Navy - AS
Air Force - 20

Review activities:
Army - AT, AV

Preparing activity:
Army - MR

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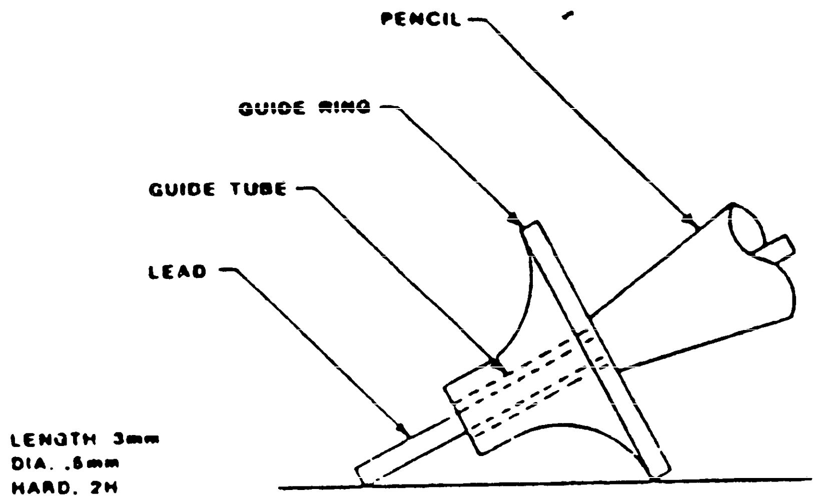
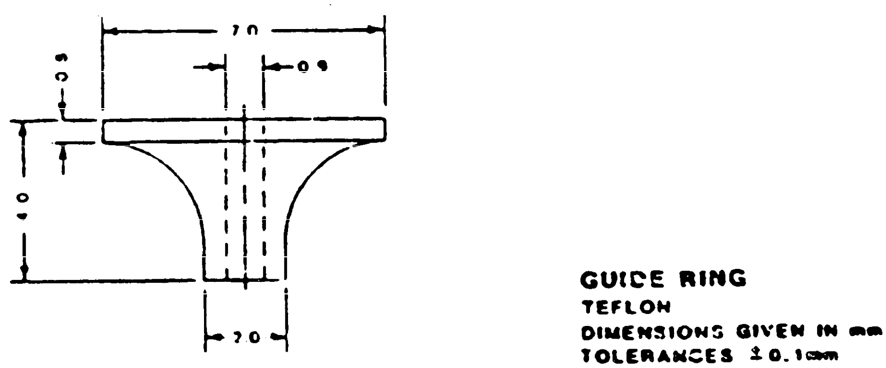


(a) Nielson-Shoe on Hsu Pencil Source



(b) Nielson Shoe

FIGURE 1. (a) Contact points on structure surface prior to breaking lead.
(b) Construction details for the Nielson Shoe. (After ASTM E976).

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☐ OTHER (Specify): ______

b. ADDRESS (Street, City, State, ZIP Code)

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER (Last, First, MI) – Optional

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