Designation: E2076/E2076M – 15

Standard Practice for Examination of Fiberglass Reinforced Plastic Fan Blades Using Acoustic Emission[1]

This standard is issued under the fixed designation E2076/E2076M; 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 provides guidelines for acoustic emission (AE) examinations of fiberglass reinforced plastic (FRP) fan blades of the type used in industrial cooling towers and heat exchangers.

1.2 This practice uses simulated service loading to determine structural integrity.

1.3 This practice will detect sources of acoustic emission in areas of sensor coverage that are stressed during the course of the examination.

1.4 This practice applies to examinations of new and in-service fan blades.

1.5 This practice is limited to fan blades of FRP construction, with length (hub centerline to tip) of less than 3 m [10 ft], and with fiberglass content greater than 15 % by weight.

1.6 AE measurements are used to detect emission sources. Other nondestructive examination (NDE) methods may be used to evaluate the significance of AE sources. Procedures for other NDE methods are beyond the scope of this practice.

1.7 *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.

1.8 *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:*[2]

E543 Specification for Agencies Performing Nondestructive Testing

E650 Guide for Mounting Piezoelectric Acoustic Emission Sensors

E750 Practice for Characterizing Acoustic Emission Instrumentation

E976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response

E1067 Practice for Acoustic Emission Examination of Fiberglass Reinforced Plastic Resin (FRP) Tanks/Vessels

E1106 Test Method for Primary Calibration of Acoustic Emission Sensors

E1316 Terminology for Nondestructive Examinations

E2374 Guide for Acoustic Emission System Performance Verification

2.2 *ASNT Documents:*[3]

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

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

2.3 *Aerospace Industries Association Document:*[4]

NAS 410 Certification and Qualification of Nondestructive Testing Personnel

2.4 *ISO Standard:*[5]

ISO 9712 Non-Destructive Testing—Qualification and Certification of NDT Personnel

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, see Terminology E1316.

[1] This practice 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] 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.

[3] Available from American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518, http://www.asnt.org.

[4] Available from Aerospace Industries Association of America, Inc. (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209-3928, http://www.aia-aerospace.org.

[5] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

*A Summary of Changes section appears at the end of this standard

4. Summary of Practice

4.1 This practice consists of subjecting individual FRP fan blades to increasing load while monitoring with sensors that are sensitive to acoustic emission (transient stress waves) caused by growing flaws.

4.2 This practice provides guidelines to determine the zonal location of structural flaws in FRP fan blades.

4.3 The test load, applied at the blade tip is calculated to provide 100 % of the maximum allowable operating (bending) load at the blade-hub interface.

4.4 This practice is intended to simulate the bending load. Torsional and centrifugal loads are not simulated by this practice.

4.5 Structurally insignificant flaws may produce acoustic emission.

5. Significance and Use

5.1 The AE examination method detects structurally significant flaws in FRP structures via test loading. The damage mechanisms that are detected in FRP include resin cracking, fiber debonding, fiber pullout, fiber breakage, delamination, and secondary bond failure.

5.2 Flaws in unstressed areas will not generate detectable AE.

5.3 Flaws located with AE may be examined by other methods.

6. Basis of Application

6.1 The following items are subject to contractual agreement between the parties using or referencing this practice.

6.2 *Personnel Qualification*

6.2.1 If specified in the contractual agreement, personnel performing examinations to this practice shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, NAS-410, ISO 9712, or a similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be specified in the contractual agreement between the using parties.

6.3 *Qualification of Nondestructive Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice E543. The applicable edition of Practice E543 shall be specified in the contractual agreement.

6.4 *Extent of Examination*—The extent of examination shall be in accordance with 10.2 unless otherwise specified.

6.5 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with Section 12 unless otherwise specified. Since acceptance criteria, for example, for reference radiographs, are not specified in this practice, they shall be specified in the contractual agreement.

6.6 *Reexamination of Repaired/Reworked Items*—Reexamination of repaired/reworked items is not addressed in this practice, and if required, shall be specified in the contractual agreement.

6.7 *Personnel Training*—It is recommended that personnel performing the examination have additional training on the following topics:

6.7.1 Basic technology of AE from FRP;
6.7.2 Failure mechanisms of FRP;
6.7.3 AE instrument and sensor checkout on FRP;
6.7.4 Loading of FRP components for AE testing;
6.7.5 Data collection and interpretation; and
6.7.6 Examination report preparation.

7. Apparatus

7.1 Essential features of the apparatus required for this practice are shown in Fig. 1. Specifications are provided on Annex A1.

7.2 Couplant must be used to acoustically couple sensors to the blade surface. Adhesives that have acceptable acoustic properties and ultrasonic couplants are acceptable.

7.3 Sensors may be held in place with elastic straps, adhesive tape, or other mechanical means. (See Guide E650.)

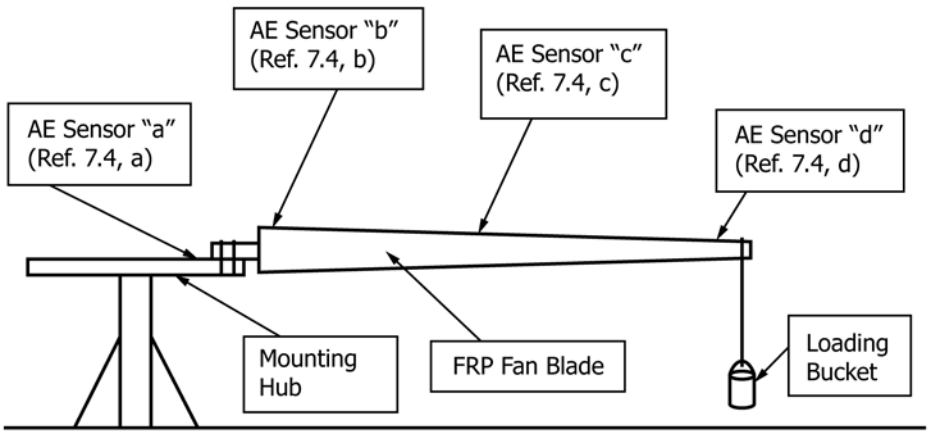

FIG. 1 Apparatus

7.4 Sensors are to be positioned on the fan mounting drive hub for background noise detection only; on the blade within 150 mm [6 in.] of the shank; on the blade midway between the shank and the blade tip; and within 150 mm [6 in.] of the blade tip for background noise detection only. Additional sensors may be added when more complete coverage is desired.

NOTE 1—The sensors indicated in Fig. 1 may be placed on either the top or bottom surface of the blade.

7.5 Instrumentation shall be capable of recording AE hits above a low-amplitude threshold, AE hits above a high-amplitude threshold (both within a specific frequency range) and have sufficient channels to localize AE sources in real time. (See Practice E750.) Hit detection is required for each channel. An AE hit amplitude measurement is recommended for sensitivity verification. Amplitude distributions are recommended for flaw characterization.

7.6 Preamplifiers may be enclosed in the sensor housing or in a separate enclosure. If a separate preamplifier is used, sensor cable length, between the sensor and the preamplifier, must not result in a signal loss of greater than 3 dB. Typically, 2 m [6 ft], is acceptable.

7.7 Power/signal cable length (between preamplifier and signal processor) shall not result in a signal loss of greater than 3 dB. Typically, 150 m [500 ft] is acceptable.

7.8 Signal processors are computerized instruments with independent channels that filter, measure, and convert analog information into digital form for display and permanent storage. A signal processor must have sufficient speed and capability to independently process data from all sensors simultaneously. The signal processor should provide capability to filter data for replay.

7.9 A video monitor is used to display processed data in various formats. Display format may be selected by the examiner.

7.10 A data storage device, such as a hard disk, is used to store data for replay and archiving.

7.11 Hard-copy capability should be available from a graphics printer or equivalent device.

8. Safety Precautions

8.1 *Safety*—All site safety requirements unique to the test location shall be met.

9. Calibration and Verification

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

9.2 Routine electronic evaluations must be performed on a monthly basis or at any time there is concern about signal processor performance. An AE electronic waveform generator should be used in routine electronic checks. Each signal processor channel must respond with peak amplitude readings within ±2 dB_{AE} of the electronic waveform generator output.

9.3 Routine sensor evaluations must be performed on a monthly basis or at any time that there is concern about the sensor performance. Peak amplitude response and electronic noise level should be recorded. Sensors can be stimulated by a pencil lead break in accordance with Guide E976. Sensors which are found to have peak amplitudes or electronic noise more than 3 dB greater than the average of the group of sensors to be used during the examination shall be replaced.

9.4 A system verification must be conducted immediately before and immediately after each examination. A system verification utilizes a mechanical device to induce stress waves into the structure. The induced stress waves must be nondestructive and simulate emission from a flaw. System performance checks verify the sensitivity of each system channel, including the couplant. See Guide E2374.

9.4.1 The preferred technique for conducting a system performance check utilizes a pencil lead break. Lead should be broken on the surface (see Fig. 5 of Guide E976) at a specified distance, typically 100 mm [4 in.] from the sensor.

9.4.2 System channels which are found to have performance outside of specified values shall be repaired or replaced. Values shall be specified such that the sensitivity of channels used in the same test differ by no more than 3 dB.

10. Test Procedure

10.1 *General Guidelines*—Each fan blade is subjected to programmed increasing tip load, up to a predetermined maximum value (test load), while being monitored by sensors that detect acoustic emission (stress waves) caused by growing structural flaws.

10.1.1 Blade tip load shall be controlled so as to not exceed a load rate of 33 % of test load per minute.

10.1.2 Background noise shall be minimized and identified. Excessive background noise is cause for suspension of the loading. In the analysis of examination results, background noise should be properly discounted, if the source is determined to be irrelevant to mechanical integrity.

10.2 *Loading*—Determine the test load from the blade manufacturer's specifications. The blade may be loaded once or twice depending upon the outcome of the first loading. If the acoustic emission activity generated by the first loading exceeds the criteria then an immediate second loading shall be applied. If the blade meets the acceptance criteria on the first loading then the second loading is not required. Fig. 2 shows the recommended loading sequence. The following is a practical way to achieve the desired blade tip load.

10.2.1 Secure the shank of the blade in an appropriate holder at its operating pitch (blade parallel to the floor). This will usually be the blade manufacturer's drive hub arrangement (see also Fig. 1).

10.2.2 Suspend an empty water container at the tip end of the blade. Padding is recommended to reduce the possibility of extraneous noise and physical damage to the surface of the blade tip.