Designation: E 1067 – 07

Standard Practice for Acoustic Emission Examination of Fiberglass Reinforced Plastic Resin (FRP) Tanks/Vessels[1]

This standard is issued under the fixed designation E 1067; 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 covers acoustic emission (AE) examination or monitoring of fiberglass-reinforced plastic (FRP) tanks-vessels (equipment) under pressure or vacuum to determine structural integrity.

1.2 This practice is limited to tanks-vessels designed to operate at an internal pressure no greater than 0.44 MPa absolute (65 psia) above the static pressure due to the internal contents. It is also applicable for tanks-vessels designed for vacuum service with differential pressure levels between 0 and 0.06 MPa (0 and 9 psi).

1.3 This practice is limited to tanks-vessels with glass contents greater than 15 % by weight.

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

1.5 The values stated in SI units are to be regarded as standard. The inch-pound units in parentheses may be approximate.

1.6 *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.* (For more specific safety precautionary information see 8.1.)

2. Referenced Documents

2.1 *ASTM Standards:* [2]

D 883 Terminology Relating to Plastics

E 543 Specification for Agencies Performing Nondestructive Testing

E 650 Guide for Mounting Piezoelectric Acoustic Emission Sensors

E 750 Practice for Characterizing Acoustic Emission Instrumentation

E 1316 Terminology for Nondestructive Examinations

E 2374 Guide for Acoustic Emission System Performance Verification

2.2 *ANSI/ASNT Standards:*

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

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

2.3 *AIA Standard:*

NAS-410 Certification and Qualification of Nondestructive Personnel (Quality Assurance Committee)[4]

3. Terminology

3.1 Complete definitions of terms related to plastics and acoustic emission will be found in Terminology D 883 and E 1316.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *count value* N_c—an evaluation criterion based on the total number of AE counts. (See A2.4 of Annex A2.)

3.2.2 *FRP*—fiberglass reinforced plastic, a glass-fiber polymer composite with certain mechanical properties superior to those of the base resin.

3.2.3 *high-amplitude threshold*—a threshold for large amplitude AE events. (See A2.3 of Annex A2.)

3.2.4 *low-amplitude threshold*—the threshold above which AE counts (N) are measured. (See A2.2 of Annex A2.)

3.2.5 *operating pressure*—the pressure at the top of a vessel at which it normally operates. It shall not exceed the design pressure and it is usually kept at a suitable level below the setting of the pressure-relieving devices to prevent their frequent opening.

3.2.6 *pressure, design*—the pressure used in design to determine the required minimum thicknesses and minimum mechanical properties.

---

[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.

Current edition approved Feb. 15, 2007. Published March 2007. Originally approved in 1985. Last previous edition approved in 2001 as E 1067 - 01.

[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.

3.2.7 *processor*—a circuit that analyzes AE waveforms. (See Section 7 and A1.8.)

3.2.8 *summing amplifier (summer, mixer)*—an operational amplifier that produces an output signal equal to a weighted sum of the input signals.

3.2.9 *zone*—the area surrounding a sensor from which AE can be detected by that sensor.

4. Summary of Practice

4.1 This practice consists of subjecting equipment to increasing pressure or vacuum while monitoring with sensors that are sensitive to acoustic emission (transient stress waves) caused by growing flaws. The instrumentation and techniques for sensing and analyzing AE data are described.

4.2 This practice provides guidelines to determine the location and severity of structural flaws in FRP equipment.

4.3 This practice provides guidelines for AE examination of FRP equipment within the pressure range stated in 1.2. Maximum test pressure (or vacuum) for an FRP vessel will be determined upon agreement among user, manufacturer, or test agency, or a combination thereof. Pressure vessels having an internal operating pressure exceeding 0.2 MPa absolute (30 psia), will normally be tested to 1.5 × operating pressure. Atmospheric storage vessels will normally be tested under maximum operating conditions. Pressure vessels having an internal pressure between 0.1 and 0.2 MPa absolute (15 and 30 psia), and vacuum vessels having an external differential pressure between 0 and 0.06 MPa (0 and 9 psi), will normally be tested to pressures in the range from 1.0 to 1.5 × operating pressure.

5. Significance and Use

5.1 The AE examination method detects damage in FRP equipment. The damage mechanisms that are detected in FRP are as follows: resin cracking, fiber debonding, fiber pullout, fiber breakage, delamination, and bond failure in assembled joints (for example, nozzles, manways, etc.). Flaws in unstressed areas and flaws that are structurally insignificant will not generate AE.

5.2 This practice is convenient for on-line use under operating stress to determine structural integrity of in-service equipment usually with minimal process disruption.

5.3 Indications located with AE should be examined by other techniques; for example, visual, ultrasound, dye penetrant, etc., and may be repaired and tested as appropriate. Repair procedure recommendations are outside the scope of this practice.

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 standard 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, 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 E 543. The applicable edition of Practice E 543 shall be specified in the contractual agreement.

6.4 *Procedures and Techniques*—The procedures and techniques to be utilized shall be as specified in the contractual agreement.

6.5 *Surface Preparation*—The pre-examination surface preparation criteria shall be in accordance with 9.2 unless otherwise specified.

6.6 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with Section 13 unless otherwise specified. Since acceptance criteria are not specified in this practice, they shall be specified in the contractual agreement.

7. Instrumentation

7.1 The AE instrumentation consists of sensors, signal processors, and recording equipment. Additional information on AE instrumentation can be found in Practice E 750.

7.2 Instrumentation shall be capable of recording AE counts and AE hits above the low-amplitude threshold, AE hits above the high-amplitude threshold within specific frequency ranges, and having sufficient channels to localize AE sources in real time. It may incorporate (as an option) peak-amplitude detection for each input channel or for groups of channels. Hit detection is required for each channel. An AE hit amplitude measurement is recommended for sensitivity verification (see Annex A2). Amplitude distributions are recommended for flaw characterization. It is preferred that AE instrumentation acquire and record count, hit, and amplitude information on a per channel basis. The AE instrumentation is further described in Annex A1.

7.3 Capability for measuring parameters such as time and pressure shall be provided. The pressure-vacuum in the vessel should be continuously monitored to an accuracy of ±2 % of the maximum test value.

8. Examination Preparations

8.1 *Safety*—All plant safety requirements unique to the examination location shall be met.

8.1.1 Protective clothing and equipment that is normally required in the area in which the examination is being conducted shall be worn.

8.1.2 A fire permit may be needed to use the electronic instrumentation.

8.1.3 Precautions shall be taken to protect against the consequences of catastrophic failure when pressure testing, for example, flying debris and impact of escaping liquid. Pressurizing under pneumatic conditions is not recommended except when normal service loads include either a superposed gas pressure or gas pressure only. Care shall be taken to avoid overstressing the lower section of the vessel when liquid test loads are used to simulate operating gas pressures.

TABLE 1 Requirements for Reduced Operating Pressure-Load Immediately Prior to Examining

% of Operating Pressure or Load, or Both	Time at Reduced Pressure or Load, or Both
10 or less	12 h
20	18 h
30	30 h
40	2 days
50	4 days
60	7 days

8.1.4 Special safety precautions shall be taken when pneumatic testing is required; for example, safety valves, etc.

8.2 *Vessel Conditioning*—The operating conditions for vessels that have been stressed previously shall be reduced prior to examining in accordance with the schedule shown in Table 1. The maximum operating pressure or load in the vessel during the past year must be known in order to conduct the AE examination properly.

8.3 *Vessel Stressing*—Arrangements should be made to stress the vessel to the operating pressure-load where possible. The stress rate shall be sufficient to expedite the examination with minimum extraneous noise. Holding stress levels is a key aspect of an acoustic emission examination. Accordingly, provision must be made for holding the pressure-load at designated check points.

8.3.1 *Atmospheric Tanks*—Process liquid is the preferred fill medium for atmospheric tanks. If water must replace the process liquid, the designer and user shall be in agreement on the procedure to achieve acceptable stress levels.

8.3.2 *Vacuum-Tank Stressing*—A controllable vacuum-pump system is required for vacuum tanks.

8.3.3 *Pressure-Vessel Stressing*—Water is the preferred medium for pressure tanks. Safe means for hydraulically increasing the pressure under controlled conditions shall be provided.

8.4 *Tank Support*—The tank shall be examined in its operating position and supported in a manner consistent with good installation practice. Flat-bottomed tanks examined in other than the intended location shall be mounted on a pad (for example, rubber on a concrete base or equivalent) to reduce structure-borne noise between the tank and base.

8.5 *Environmental*—The normal minimum acceptable vessel wall temperature is 4°C (40°F).

8.6 *Noise Reduction*—Noise sources in the examination frequency and amplitude range, such as rain, spargers, and foreign objects contacting the tank, must be minimized since they mask the AE signals emanating from the structure. The inlet should be at the lowest nozzle or as near to the bottom of the vessel as possible, that is, below the liquid level. Liquid falling, swirling, or splashing can invalidate data obtained during the filling phase.

8.7 *Power Supply*—A stable grounded power supply, meeting the specification of the instrumentation, is required at the examination site.

8.8 *Instrumentation Settings*—Settings will be determined as described in Annex A2.

9. Sensors

9.1 *Sensor Mounting*—Refer to Practice E 650 for additional information on sensor mounting. Location and spacing of the sensors are discussed in 9.5. Sensors shall be placed in designated locations with a couplant between the sensor and examination article. One recommended couplant is silicone-stopcock grease. Care must be exercised to assure that adequate couplant is applied. Sensors shall be held in place utilizing methods of attachment which do not create extraneous signals. Methods of attachment using crossed strips of pressure-sensitive tape or suitable adhesive systems, may be considered. Suitable adhesive systems are those whose bonding and acoustic coupling effectiveness have been demonstrated. The attachment method should provide support for the signal cable (and preamplifier) to prevent the cable(s) from stressing the sensor or pulling the sensor away from the examination article causing loss of coupling.

9.2 *Surface Contact*—Reliable coupling between the sensor and tank surface shall be assured and the surface of the vessel in contact with the sensor shall be clean and free of particulate matter. Sensors should be mounted directly on the tank surface unless integral waveguides shown by test to be satisfactory are used. Preparation of the contact surface shall be compatible with both sensor and structure modification requirements. Possible causes of signal loss are coatings such as paint and encapsulants, surface curvature, and surface roughness at the contact area.

9.3 *High-Frequency Sensor*—(See Annex A1.) Several high-frequency channels are used for zone location of emission sources. Greater attenuation of stress waves at higher frequencies result in smaller zones of sensitivity for high-frequency sensors.

9.4 *Low-Frequency Sensor*—(See Annex A1.) Low-frequency channels are less affected by attenuation; therefore, they can be used to identify flaws in a large zone. If significant activity is detected on the low-frequency channels, and not on high-frequency channels, consideration should be given to relocating high-frequency sensors. It should be noted, however, that low-frequency channels are more susceptible to background noise.

9.5 *Locations and Spacings*—Locations on the vessel shell are determined by the need to detect structural flaws at critical sections; for example, high-stress areas, geometric discontinuities, nozzles, manways, repaired regions, support rings, and visible flaws. Spacings are governed by the attenuation of the FRP material.

9.5.1 *Attenuation Characterization*—Typical signal propagation losses shall be determined according to one of the following procedures. These procedures provide a relative measure of the attenuation, but may not be representative of genuine AE activity. It should be noted that the peak amplitude from a mechanical pencil lead break may vary with surface hardness, resin condition, and cure. In both cases the attenuation characterization should be made above the liquid line.

9.5.1.1 For acoustic emission instrumentation with amplitude analysis: Select a representative region of the vessel away from manways, nozzles, etc. Mount a high-frequency AE sensor and locate points at distances of 150 mm (6 in.) and 300