



Designation: E2598/E2598M – 21

# Standard Practice for Acoustic Emission Examination of Cast Iron Yankee and Steam Heated Paper Dryers<sup>1</sup>

This standard is issued under the fixed designation E2598/E2598M; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope\*

1.1 This practice is no longer being updated but is being retained for historical value due to the procedures herein that are unique to the AE community.

1.2 This practice provides guidelines for carrying out acoustic emission (AE) examinations of Yankee and Steam Heated Paper Dryers (SHPD) of the type to make tissue, paper, and paperboard products.

1.3 This practice requires pressurization to levels used during normal operation. The pressurization medium may be high temperature steam, air, or gas. The dryer is also subjected to significant stresses during the heating up and cooling down periods of operation. Acoustic Emission data maybe collected during these time periods but this testing is beyond the scope of this document.

1.4 The AE measurements are used to detect, as well as, localize emission sources. Other methods of nondestructive testing (NDT) may be used to further evaluate the significance of acoustic emission sources.

1.5 *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 are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *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 Recom-*

*mendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>2</sup>

[A278/A278M Specification for Gray Iron Castings for Pressure-Containing Parts for Temperatures Up to 650 °F \(350 °C\)](#)

[E543 Specification for Agencies Performing Nondestructive Testing](#)

[E569/E569M Practice for Acoustic Emission Monitoring of Structures During Controlled Stimulation](#)

[E650 Guide for Mounting Piezoelectric Acoustic Emission Sensors](#)

[E976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response](#)

[E1316 Terminology for Nondestructive Examinations](#)

[E2374 Guide for Acoustic Emission System Performance Verification](#)

### 2.2 ASNT Standards:<sup>3</sup>

[SNT-TC-1A Recommended Practice for Nondestructive Testing Personnel](#)

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

## 3. Terminology

3.1 *Definitions*—See Terminology [E1316](#) for general terminology applicable to this practice.

## 4. Summary of Practice

4.1 Each mounted sensor, on the cast iron vessel, monitors while the vessel is stationary and pressurized to normal operating pressure. The vessel may be at ambient, or operating 120 °C–230 °C [250 °F–450 °F] temperature.

<sup>1</sup> 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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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

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

4.2 Each mounted AE sensor is connected to an acoustic emission signal processor. After a monitoring period (up to 10 min) and pre-examination sensor sensitivity checks, pressurization can begin.

#### 4.3 Location

4.3.1 *Zone Location*—Each channel shall have the same system examination threshold. A simulated AE source generated anywhere on the vessel shall be detected by at least one sensor.

4.3.2 *Source Location*—All location data resulting from analysis shall be presented in a manner consistent with the previously established calibration accuracy. The simulated AE source generated in each structure mounted sensor array shall be detected by the minimum number of sensors required to locate the source within  $\pm 5\%$  of sensor spacing.

4.4 Due to the potential for gasketed interfaces (at the heads/manway), multiple metal combinations (metalspray, cast steel-cast iron combinations), high vessel temperature, or random variations in the material velocity of cast iron, accurate source location ( $\pm 5\%$  sensor spacing) may not always be possible.

4.5 Once the AE sensor source is localized, further evaluation is begun by observing a “history” of events involving the area [Head tilt (corrosion induced head strain), leak repair, objects through the nip (working contact with another roll), etc.]. This may give further direction to the selection of the NDE method to use for follow-up examination of the AE indication area.

4.6 Secondary examination establishes presence of flaws and measures flaw dimensions.

4.7 Cast iron Yankee dryers can be up to 6.7 m [22 ft] in diameter, 7.3 m [24 ft] long, and weigh 90 000 Kg [200 000 lb], or more. Vessel thickness measurements are available from the paper/tissue machine operator. Cast iron is a brittle metal and has no specific yield point. Yankee dryers must maintain specific dimensional tolerances. When a pressurized Yankee or steam heated paper dryer (SHPD) remains stationary, it fills with condensate at a rapid rate. In an hour, a steam pressurized Yankee or SHPD can fill half way with condensate, doubling the weight on the frame, and the floor. Some Yankee owners have corporate requirements that a cast iron Yankee dryer remain stationary for  $\frac{1}{2}$  hour, then rotation is required. Permission is required, if the Yankee is to remain stationary for more time. This issue should be discussed with the responsible person prior to the examination.

4.8 Yankee dryers operate under a heated hood. The hood is in close proximity to the Yankee shell and allows only inches of clearance for the top half of the vessel.

4.9 Cast iron steam heated paper machine dryers are 1.8 m [6 ft] in diameter, or more, and may be 9 m [30 ft] long.

4.10 Gray cast iron experiences a continuing reduction in elastic modulus as it is stressed to increasing higher levels. It is prudent not to stress grey cast iron material beyond its operating stress level.

4.11 Flaws to be found are the same as those in any cast and machined product. Attempts have been made to characterize

strength properties of cast irons in compact tension tests. In a TAPPI sponsored laboratory study, two out of three cast iron compact tension specimens experienced unplanned failures. From that experience, it was cautioned that “cracks initiated and grew faster than expected resulting in brittle fracture before the process could be halted.” The failure of these two coupons demonstrated the rate in which cracks can grow in these materials and the material’s inability to stop a crack once it begins to grow. In each case, crack advance was extremely rapid and without warning.<sup>4</sup>

4.12 *Maximum Examination Pressure*—Maximum Allowable Working Pressure for cast iron vessels is set based on ASME (Section VIII) pressure calculations based on thickness, radius, and material strength values, and will not exceed 11 bar [160 psi] and 230 °C [450 °F] (Specification A278/A278M). When vessels are pressurized, anomalies produce emission at pressures less than normal fill pressure. Historically, if there is damage in a cast iron pressure boundary, AE activity will begin at load/stress levels less than 50 % of operating. Defects as small as 3 mm [ $\frac{1}{8}$  in.] have been found using AE, during steam pressurization to operating pressure.

4.13 Pressure increments should not exceed 350 millibar/minute [5 psi/minute]. If pressurization medium is to be steam, the Yankee should have been through the warm-up process.

4.14 Yankee dryers may receive a subsequent examination, if necessary, after the Yankee is rotated to remove any condensate present.

4.15 *Pressurization Schedule*—Pressurization should proceed at rates that allow achieving maximum examination pressure within a 30 min period. During pressurization, pressure holds are not necessary; however, they may be useful for reasons other than measurement of AE. Pressure hold upon achieving maximum examination pressure may be up to 30 min.

4.16 Excess background noise may distort AE data or render the AE measurements useless. Users must be aware of the following common sources of background noise: (measurable filling or flow noise); mechanical contact with the vessel by objects; electromagnetic interference (EMI) from cranes, and radio frequency interference (RFI) from nearby broadcasting facilities and from other sources; leaks at pipe or hose connections, or rain drops. This practice should not be used if background noise cannot be eliminated or controlled.

4.17 Other nondestructive test methods may be used to evaluate the significance of AE sources. Magnetic particle, ultrasonic, and radiographic examinations have been used to establish circumferential position, depth, and dimensions of flaws that produce AE. Procedures for using other NDT methods are beyond the scope of this practice.

## 5. Significance and Use

5.1 Cast iron Yankee dryers can be up to 6.7 m [22 ft] in diameter, 7.3 m [24 ft] long, and weigh 91 000 Kg [100 tons],

<sup>4</sup> Alleveto, C., and Williams D., Acoustic Emission Evaluation of Yankee Dryer Shell Material, 1991 TAPPI Engineering Conference Proceedings, pages 475-480.

or more (refer to Fig. 1). Vessel thickness measurements are available from the paper/tissue machine operator. Cast iron is a brittle metal and has no specific yield point. Yankee dryers must maintain specific dimensional tolerances. When a pressurized Yankee or steam heated paper dryer (SHPD) remains stationary, it fills with condensate at a rapid rate. In an hour, a steam pressurized Yankee or SHPD can fill half way with condensate, doubling the weight on the frame, and the floor. Some Yankee owners have corporate requirements that a cast iron Yankee dryer remain stationary for ½ h, then rotation is required. Permission is required, if the Yankee is to remain stationary for more time. This issue should be discussed with the responsible person prior to the examination.

5.2 Yankee dryers operate under a heated hood. The hood is in close proximity to the Yankee shell and allows only inches of clearance for the top half of the vessel.

5.3 Cast iron steam heated paper machine dryers are 2 m [6 ft] in diameter, or more, and may be 9 m [30 ft] long.

5.4 Grey cast iron experiences a continuing reduction in elastic modulus as it is stressed to increasing higher levels. It is prudent not to stress grey cast iron material beyond its operating stress level.

5.5 Flaws to be found are the same as those in any cast and machined product. Attempts have been made to characterize strength properties of cast irons in compact tension tests. In a TAPPI sponsored laboratory study, two out of three cast iron compact tension specimens experienced unplanned failures. From that experience it was cautioned that cracks initiated and grew faster than expected resulting in brittle fracture before the process could be halted. The failure of these two coupons demonstrated the rate in which cracks can grow in these materials and the material's inability to stop a crack once it begins to grow. In each case, crack advance was extremely rapid and without warning. (See Note 1.)

NOTE 1—Alleveto, C., and Williams D., Acoustic Emission Evaluation of Yankee Dryer Shell Material, 1991 TAPPI Engineering Conference Proceedings, pages 475-480.

5.6 *Maximum Examination Pressure*—Maximum Allowable Working Pressure for cast iron vessels is set based on ASME (Section VIII) pressure calculations based on thickness, radius, and material strength values, and will not exceed 10 bar [160 psi] and 230 °C [450 °F] (Specification A278/A278M). When vessels are pressurized, anomalies produce emission at pressures less than normal fill pressure. Historically, if there is damage in a cast iron pressure boundary, AE activity will begin at load/stress levels less than 50 % of operating. Defects as small as 3 mm [1/8 in.] have been found using AE, during steam pressurization to operating pressure.

5.7 Pressure increments should not exceed 0.35 bar [5 psi] per minute. If pressurization medium is to be steam, the Yankee should have been through the warm-up process.

5.8 Yankee dryers may receive a subsequent examination, if necessary, after the Yankee is rotated to remove any condensate present.

5.9 *Pressurization Schedule*—Pressurization should proceed at rates that allow achieving maximum examination pressure within a 30 minute period. During pressurization, pressure holds are not necessary; however, they may be useful for reasons other than measurement of AE. Pressure hold upon achieving maximum examination pressure may be up to 30 min.

5.10 Excess background noise may distort AE data or render the AE measurements useless. Users must be aware of the following common sources of background noise: (measurable flow noise); mechanical contact with the vessel by objects; electromagnetic interference (EMI) from cranes, and radio frequency interference (RFI) from nearby broadcasting facilities and from other sources; leaks at pipe or hose connections,



**FIG. 1 Yankee Dryer Drum**



or rain drops. This practice should not be used if background noise cannot be eliminated or controlled.

5.11 Other Non-destructive test methods may be used to evaluate the significance of AE sources. Magnetic particle, ultrasonic, and radiographic examinations have been used to establish circumferential position, depth, and dimensions of flaws that produce AE. Procedures for using other NDT methods are beyond 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 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, 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 identified 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 Specification E543. The applicable edition of Specification E543 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 *Extent of Examination*—The extent of examination includes the entire pressure vessel unless otherwise specified.

6.6 *Reporting Criteria/AE Evaluation Criteria*—Examination results will be reported and compared with AE evaluation criteria. Since acceptance criteria (for example, reference radiographs) are not specified in this practice, they shall be specified in the contractual agreement.

**7. Apparatus**

7.1 Essential features of the apparatus required for this practice are provided in Fig. 2. Full specifications are in Annex A1.

7.2 Couplant must be used to acoustically connect sensors to the vessel surface. Adhesives that have acceptable acoustic properties, and adhesives used in combination with traditional couplants, are acceptable.

7.3 Sensors should be mounted in accordance with Fig. 3 for location analysis purposes. Sensors may be held in place with magnets, adhesive tape, or other mechanical means. High temperature waveguides may be used but they cannot be welded to the shell of the drum. The attachment method to be used should be reviewed with the dryer owner prior to use.

7.4 The AE sensors are used to detect stress waves produced by cast iron anomalies. Sensors must be held in contact with the vessel wall to ensure adequate acoustic coupling (see Guide E650). Sensors shall be capable of operating in the examination environment (Some operating environments may be up to 230 °C [450 °F]).

7.5 The preamplifier should be kept as far as possible away from the heat. If a separate preamplifier is used, cable length, between sensor and preamp, must not exceed 2 m [6 ft].

7.6 Power/signal cable length (that is, the maximum cable length between the preamplifier and processor) should not exceed the manufacturers specification for the device.

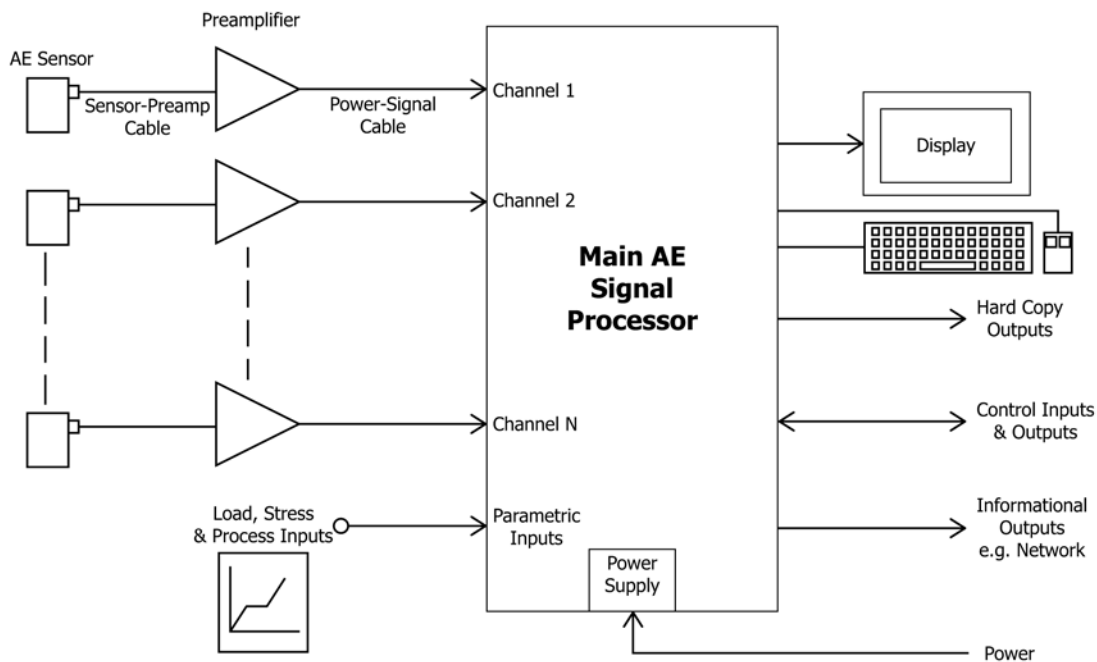
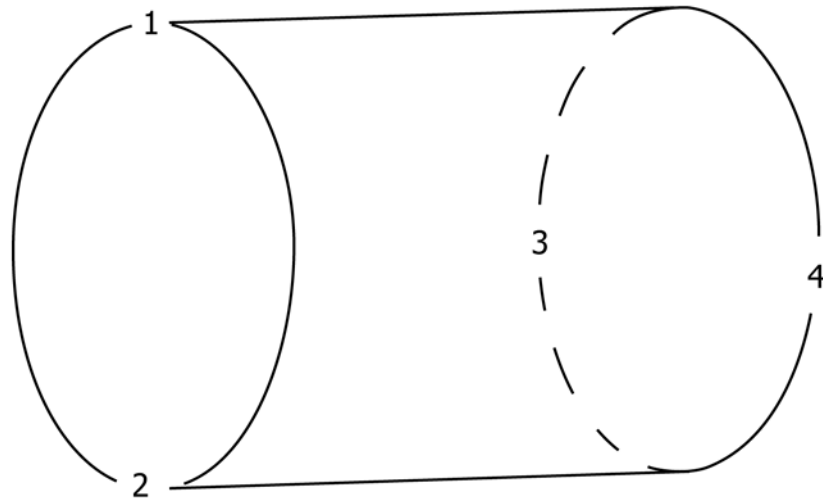


FIG. 2 AE System Block Diagram with Essential Features



**FIG. 3 Preferred AE Sensor Positions on Yankee Heads, with Channel Number**

7.7 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 capacity to independently process data from all sensors simultaneously. The signal processor should provide capability to digitally filter data for replay.

7.7.1 A video monitor should display processed examination data in various formats. Display format may be selected by the equipment operator.

7.7.2 A digital data storage device, such as a hard disk drive, CD, DVD, flash drive or other electronic storage media may be used to provide data for replay or for archives.

7.7.3 Hard copy capability should be available from a printer or equivalent device.

## 8. Safety Precautions

8.1 As in any pressurization of metal vessels, ambient temperature should not be below the ductile-brittle transition temperature of the pressure vessel construction material.

8.2 This document does not address personnel safety concerns when examining high temperature items.

## 9. Calibration and Verification

9.1 Annual calibration and verification of AE sensors, preamplifiers (if applicable), signal processor, and AE electronic waveform generator (or simulator) should be performed. Equipment should be adjusted so that it conforms to 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).

9.2 Routine electronic evaluations must be performed any time there is concern about signal processor performance. An AE electronic waveform generator or simulator, should be used in making evaluations. Each signal processor channel must respond with peak amplitude reading within  $\pm 2$  dB of the electronic waveform generator output.

9.3 A system performance verification must be conducted immediately before, and immediately after, each examination. A performance verification uses a mechanical device to induce stress waves into the material under examination, at a specified distance from each sensor. Induced stress waves stimulate a sensor in the same way as emission from a flaw. Performance verifications verify performance of the entire system (including couplant). (Refer to Guide E2374 for AE system performance verification techniques).

9.3.1 The preferred technique for conducting a performance verification is a pencil lead break (PLB). Lead should be broken on the material surface at a specified distance from each sensor. The 2H lead, 0.3-mm [0.012-in.] diameter, and 2 to 3-mm [0.08 to 0.12-in.] long should be used (see Figure 5 of Guide E976 and Guide E2374).

9.3.2 *Auto Sensor Test (AST)*—An electromechanical device such as a piezoelectric pulser (and sensor which contains this function) can be used in conjunction with pencil lead break as a means to assure system performance. This device can be used to replace the PLB post examination, system performance verification. (Refer to Guide E2374.)

## 10. Procedure

10.1 Visually examine accessible exterior surfaces of the vessel. Note observations in examination report.

10.2 Use procedures specified in Guide E650 for mounting AE sensors. Sensors must be at the same angular position and should be located at each end of the vessel so that the AE system can determine axial locations of sources in as much of the vessel as possible.

10.3 Adjust signal processor settings.

10.4 Perform a system performance verification at each sensor (see 9.3). Verify that peak amplitude is greater than a specified value. If source location is used, verify that the AE system displays a correct location (see Note 2) for the mechanical device that is used to produce stress waves.