Designation: E2907/E2907M – 13

Standard Practice for Examination of Paper Machine Rolls Using Acoustic Emission from Crack Face Rubbing[1]

This standard is issued under the fixed designation E2907/E2907M; 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 non-pressure, paper machine rolls.

1.2 This practice utilizes a slow rotation of the roll to produce a full load cycle where load is provided by the weight of the roll suspended from its bearings or other journal support mechanism(s).

1.3 This practice is used for detection of cracks and other discontinuities in rolls that produce frictional acoustic emission during rotation.

1.4 The AE measurements are used to detect or locate emission sources, or both. Other nondestructive test (NDT) methods must be used to evaluate the significance of AE sources. Procedures for other NDT techniques are beyond the scope of this practice. See Note 1.

NOTE 1—Traditional AE examination, magnetic particle examination, shear wave ultrasonic examination and radiography are commonly used to establish the exact position and dimensions of flaws that produce AE.

1.5 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 standards.

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. Specific precautionary statements are given in Section 8.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E543 Specification for Agencies Performing Nondestructive Testing

E650 Guide for Mounting Piezoelectric Acoustic Emission Sensors

E976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response

E1316 Terminology for Nondestructive Examinations

E2075 Practice for Verifying the Consistency of AE-Sensor Response Using an Acrylic Rod

E2374 Guide for Acoustic Emission System Performance Verification

E2598 Practice for Acoustic Emission Examination of Cast Iron Yankee and Steam Heated Paper Dryers

2.2 *ASNT Standards:*[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 *AIA Document*[4]

NAS-410 Certification and Qualification of Nondestructive Testing Personnel

3. Terminology

3.1 *Definitions*—See Terminology E1316 for general terminology applicable to this practice.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *crack face rubbing*—physical displacement of existing crack surfaces as load is changed.

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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.

3.2.2 *crack face rubbing emission*—acoustic emission produced by (frictional mechanisms) within existing cracks that are subjected to a change in load.

3.2.3 *crack-face-rubbing emission*—is one form of tribo-acoustic emission.

3.2.4 *tribo-acoustic emission*—stress waves produced by rubbing of surfaces.

4. Summary of Practice

4.1 The type of paper machine roll that has been most commonly examined using this technique is known as a "felt" roll.

4.2 The felt must be removed or loosened such that a felt roll can be rotated without causing background noise. Electromagnetically "jogging" the roll may be a possibility, depending on the availability of electricity in the mill.

4.3 The roll is slowly rotated through 360 degrees, then rotated back to the original 0 degrees orientation. (Test time is approximately 60 seconds.)

4.4 This examination procedure describes a technique whereby AE is detected from the rubbing of existing crack surfaces. Excessive loading to induce crack propagation is not required.

4.5 The AE sensors are mounted on each end of the roll (bearing journal or shell, or both).

4.6 Sensors are connected to an acoustic emission signal processor. The signal processor uses single channel data for zone location and measured times of arrival to determine linear location of emissions sources.

4.7 If measured emission exceeds a prescribed level (that is, specific areas produce enough AE activity), then such locations are considered NDT indications and should receive secondary NDT examination to determine the severity of the indication.

4.8 Secondary examination confirms presence of flaws and measures flaw dimensions.

4.9 If one dimension of the flaw aspect ratio exceeds a prescribed limit (that is, a conservative limit that is based on construction material, wall thickness, fatigue crack growth estimates, and fracture critical flaw depth calculations), then the roll must be removed from service.

5. Significance and Use

5.1 Paper machine rolls can range in size from 2.4 to 9 m [8 to 30 ft] long, with a shell thickness of from 12.5 to 75 mm [0.5 to 3 in.,] and 300 to 1200 mm [12 to 48 in.] diameter. Depending on purpose, paper machine rolls can weigh as little as 60 000 kg [13 000 lb] to as much as 27 500 kg [60 000 lb].

5.2 If indications are found during this procedure it can be repeated, with additional sensors to refine source location accuracy.

5.3 Removal of rolls for traditional NDT examination may be impractical and may not be sensitive enough to locate small defects.

5.4 Traditional AE examination, whereby the roll is subjected to load greater than service load to detect crack extension, risks damage to the roll and is best employed as a follow-up NDT examination.

5.5 Manual rotation through a full revolution subjects existing cracks to tensile and compressive forces which can open and close existing cracks, and cause friction at the crack surfaces.

5.6 Excess background noise (overhead cranes, nearby maintenance activities) may distort AE data or render it useless. Users must be aware of the following common sources of background noise: bearing noise (lack of lubrication, spalling, and so forth), mechanical contact with the roll by other objects, electromagnetic interference (EMI) and radio frequency interference (RFI) from nearby broadcasting facilities and from other sources. This practice should not be used if background noise cannot be eliminated or controlled.

5.7 Other Non-destructive test methods may be used to evaluate the significance of AE indications. Traditional AE has been used to confirm the existence of the AE indication and fine tune the location. Magnetic particle, ultrasonic and radiographic examinations have been used to establish the position, depth and dimensions of the indication. 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*—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 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 Practice E543. The applicable edition of Practice E543 shall be specified in the contractual agreement.

6.4 *Extent of Examination*—The extent of examination includes the entire roll unless otherwise specified.

6.5 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with Section 11 unless otherwise specified. Since acceptance criteria (for example, 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.

7. Apparatus

7.1 Essential features of the apparatus required for this practice are provided in Fig. 1. Full specifications are in Annex A1.

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

7.3 Sensors may be held in place with magnets, elastic strips, adhesive tape, or other mechanical means.

7.4 The AE sensors are used to detect frictionally induced stress waves emanating from the crack surface. Sensors must be held in contact with the roll to ensure adequate acoustic coupling.

7.5 A preamplifier may be enclosed in the sensor housing or in a separate enclosure. 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, cable between preamp and signal processor) shall not exceed 150 m [500 ft]. See A1.5.

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 filter data for replay. A printer should be used to provide hard copies of examination results.

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 data storage device, such as a hard drive, 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 If the roll has been allowed to cool to a very low level, the operator should be aware of the ductile-brittle transition temperature of the roll's construction material.

9. Calibration and Verification

9.1 Annual calibration and verification of signal processor (particularly the signal processor time reference), 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 calibrations must have current accuracy certification that is traceable to the National Institute for Standards and Technology (NIST) or equivalent.

9.2 Routine electronic evaluation of the signal processor should be performed monthly and any time there is concern about signal processor performance. An AE electronic waveform generator should be used in making evaluations. Each signal processor channel must respond with peak amplitude reading within ±2 dBV of the electronic waveform generator output.

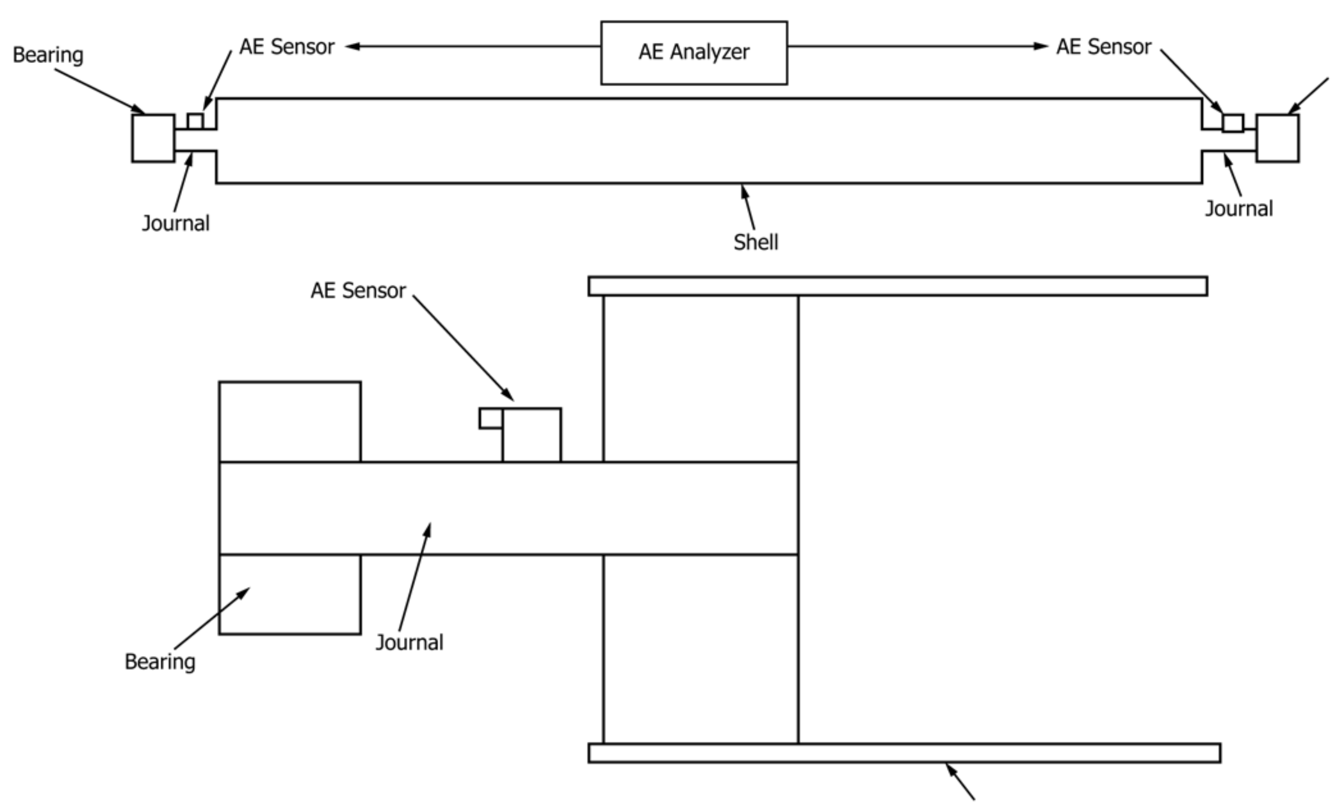

FIG. 1 Essential Features of the Apparatus

9.3 Routine evaluation of the sensors should be performed monthly. An accepted procedure for this purpose is found in Practice E2075 and Guide E976.

9.4 Pre-examination and post-examination system performance verification must be conducted immediately before and after each examination. System performance verification uses a mechanical (or electro-mechanical) device to induce stress waves into the roll at a specified distance from each sensor. Induced stress waves stimulate a sensor in the same way as emission from a flaw. System performance verification confirms performance of the entire system (including sensors, cables, and couplant). Procedures for system performance verification are found in Guide E2374.

9.4.1 The preferred technique for conducting a system performance verification is a pencil lead break (PLB). Lead should be broken on the roll surface no less than 10 cm [4 in.] from the sensor. The 2H lead, 0.3 mm [0.012 in.] diameter, 3 mm [0.120 in.] long should be used (see 4.3.2 of Guide E976).

9.4.2 *Auto Sensor Test (AST)*—An electromechanical device such as piezoelectric pulser (and sensor which contains this function) can be used in lieu of or in conjunction with pencil lead break as a means to ensure system performance.

10. Procedure

10.1 Obtain a drawing of the paper machine indicating the designation and position of each roll to be examined.

10.2 Visually examine accessible exterior surfaces of the roll to be examined. Note observations in examination report.

10.3 Verify that the roll is isolated from extraneous noise sources. Felt must be removed or loosened to allow free rotation of the roll without friction. When the roll cannot be completely isolated, indicate, in the examination report, external sources which could have produced emission.

10.4 Clean the area on which the sensor is to be mounted down to bare metal. This can generally be done with a paint scraper.

10.5 Mount an AE sensor at each end of the roll (see Fig. 1 for typical sensor placement). Use procedures specified in Guide E650. Sensors must be at the same angular position and should be located at each end of the roll so that the AE system can determine axial locations of sources in as much of the roll as possible. See Note 2.

NOTE 2—Sensors must be mounted as close to the roll end as possible to optimize linear source location accuracy (refer to Fig. 1). Mounting on the bearing journal or on the shell, close to the end, is acceptable.

10.6 Align the sensor connector/cable such that the cable will not pull on the sensor as the roll is rotated.

10.7 Adjust signal processor settings. See Appendix X1 for example.

10.8 Perform a pre-examination, system performance verification at each sensor (see 9.4). Verify that peak amplitude is greater than a specified value (see Table X1.1). Verify that the AE system displays a correct location (see Note 3).

NOTE 3—If desired location accuracy cannot be attained with sensors at two axial locations, then more sensors should be added to reduce sensor spacing.

10.9 Monitor and record background noise for ten minutes. If background noise is excessive, the source must be determined and eliminated.

10.10 Begin manual rotation of the roll. Halt rotation at 360 degrees, then rotate the roll back to the original position. The rotation and return to the original position should take approximately one minute and data should be collected during the entire process.

10.11 Monitor the examination by observing displays that show plots of AE activity versus time and axial location. If an unusual response (in the operator's judgment) is observed, interrupt the examination and conduct an investigation. If data has been contaminated, the rotation process can be repeated.

10.12 Store all data on mass storage media.

10.13 Perform a post-examination system performance verification at each sensor (see 9.4). Verify that peak amplitude is greater than a specified value (see Table X1.1).

10.14 Terminate data acquisition and remove sensors.

10.15 Raw AE data should be filtered to eliminate emission from non-structural sources, for example, electronic background noise.

10.16 Replay examination data. Examine the location distribution plots (AE events versus axial location), time based plots and correlation/distribution plots.

10.17 Based on data replay, determine whether secondary examination (ultrasonic, magnetic particle, and so forth) is required. See X1.3.

11. Report

11.1 Prepare a written report from each examination. Report the following information:

11.1.1 Name of the owner of the roll.

11.1.2 Examination date and location.

11.1.3 Previous examination history. See Note 4.

NOTE 4—If the operator is aware of situations where the roll has malfunctioned in any way this should be described in the report.

11.1.4 Locations of AE sources that exceed acceptance criteria. Location shall include distance from the front (tended) end of roll and the designation of the roll from the machine drawing.

11.1.5 The propagation velocity used during AE location determination shall be reported.

11.1.6 Visual examination results.

11.1.7 Historical information from the owner.

11.1.8 Signature of the examiner.

12. Keywords

12.1 acoustic emission; paper machine rolls; fatigue crack growth

ANNEX

(Mandatory Information)

A1. INSTRUMENTATION SPECIFICATIONS

A1.1 Sensors

A1.1.1 The AE sensors shall have high sensitivity within the frequency band of 100 to 300 kHz. Sensors may be broad band or resonant.

A1.1.2 Sensitivity shall be greater than –77 dBV (referred to 1V/μbar [1V/14.5 μPSI], determined by face-to-face ultrasonic pulsing) within the frequency range of intended use.

A1.1.3 Sensitivity within the range of intended use shall not vary more than 3 dB over the intended range of temperatures in which sensors are used.

A1.1.4 Sensors shall be shielded against electromagnetic interference through proper design practice or differential (anticoincidence) element design, or both.

A1.1.5 Sensors shall be electrically isolated from conductive surfaces by means of a shoe (a wear plate).

A1.2 Signal Cable

A1.2.1 The sensor signal cable which connects sensor and preamplifier shall not reduce sensor output more than 3 dB. Two meters [6 ft] is a typical maximum length. Integral preamplifier sensors meet this requirement. They have inherently short internal signal cables.

A1.2.2 Signal cable shall be shielded against electromagnetic interference. Standard coaxial cable is generally adequate.

A1.3 Couplant

A1.3.1 A couplant shall provide adequate ultrasonic coupling efficiency throughout the examination.

A1.3.2 The couplant must be temperature stable over the temperature range intended for use.

A1.3.3 Adhesives may be used if they satisfy ultrasonic coupling efficiency and temperature stability requirements.

A1.4 Preamplifier

A1.4.1 The preamplifier shall have noise level no greater than 5 μV rms (referred to a shorted input) within the bandpass range.

A1.4.2 The preamplifier gain shall vary no more than ±1 dB within the frequency band and temperature range of use.

A1.4.3 The preamplifier shall be shielded from electromagnetic interference.

A1.4.4 The preamplifiers of differential design shall have a minimum of 40 dB common mode rejection.

A1.4.5 The combination of preamplifier and signal processor shall include a bandpass filter with a minimum of 24 dB/octave signal attenuation above and below the 100 to 300 kHz frequency band.

A1.5 Power/Signal Cable

A1.5.1 The power/signal cables provide power to preamplifiers and conduct amplified signals to the main processor. These shall be shielded against electromagnetic interference. Standard coaxial cable is generally adequate. Signal loss from a power/signal cable shall be no greater than 3 dB.

A1.6 Power Supply

A1.6.1 A stable, grounded power supply that meets the signal processor manufacturer's specification shall be used.

A1.7 Signal Processor

A1.7.1 The electronic circuitry gain shall be stable within ±2 dB in the temperature range from 4 to 40°C [40 to 100°F].

A1.7.2 Threshold shall be accurate within ±1 dB (based on gain accuracy).

A1.7.3 Measured AE parameters shall include: threshold crossing counts, peak amplitude, arrival time, rise time, and duration for each hit.

A1.7.4 The counter circuit shall count threshold crossings within an accuracy of ±3 counts.

A1.7.5 Peak amplitude shall be accurate within ±1 dBV (based on gain accuracy).

A1.7.6 Arrival time at each channel shall be accurate to within ±3 μseconds.

A1.7.7 Duration shall be accurate to within ±10 %.

A1.7.8 Rise time shall be accurate to ±10 %.

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLE INSTRUMENT SETTINGS AND REJECTION CRITERIA

X1.1 A database and rejection criteria are established for non-pressure, paper machine rolls (felt rolls).

X1.2 Criteria for determining the need for secondary examination were established while working with AE equipment with setup conditions listed in Table X1.1.

X1.3 The need for secondary examination is based on location distribution plots (that is, exact solution plots of AE events versus axial location) and characteristics of individual channel (zone location) data.

X1.3.1 Exact solution source location rejection criteria—two or more AE events of any amplitude (greater than 50 dB) within a 20 cm [8 in.] axial distance or one AE event with amplitude greater than 65 dB.

TABLE X1.1 Acoustic Emission Equipment, Characteristics, and Setup Conditions

Sensor sensitivity	-77 dBV ref. 1V/µbar [14.5 µPSI]
Couplant	Grease
Preamplifier gain	40 dB [×100]
Preamplifier filter	100 to 300–kHz bandpass
Power/signal cable length	<150 m [500 ft.]
Signal processor threshold	26 dB_{AE}
Signal processor filter	100 to 300–kHz bandpass
Dead time	10 ms
Background noise	<26 dB_{AE}

X1.3.2 Zone location rejection criteria—five hits with amplitude greater than 50 dB from any sensor.

X1.3.3 Should a roll produce data which exceeds the rejection criteria, the report should indicate the linear position or location zone as a guide from the follow-up examination.

X2. EXAMPLE TEST RESULTS

X2.1 See Figs. X2.1 and X2.2

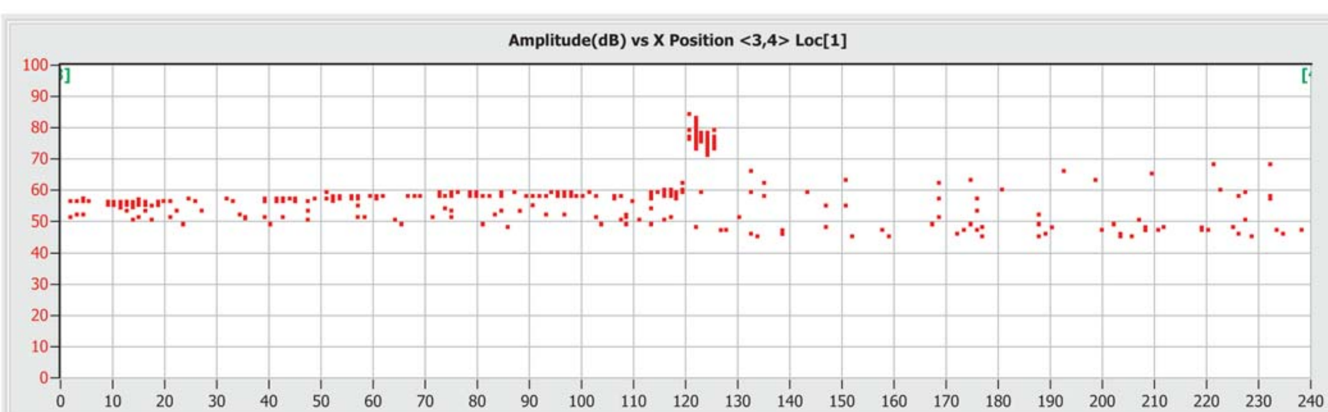

FIG. X2.1 Location Plot for 20 ft long reel spool. High amplitude source, AE indication area at “125”, was from two cracks circumferentially oriented from a balance weight mounting hole in the shell.

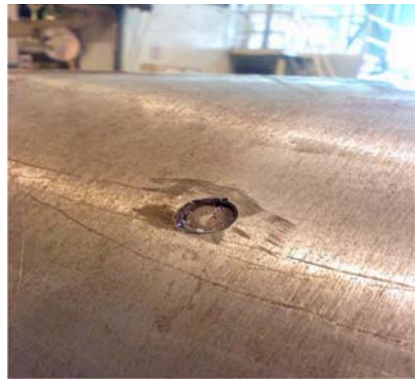

FIG. X2.2 (Reference Fig. X2.1. One circumferential crack on the ID was ~6 mm [¼ in.] long. The other crack on the OD was ~12 mm [½ in.] long.

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