Designation: E 1118 – 00

Standard Practice for Acoustic Emission Examination of Reinforced Thermosetting Resin Pipe (RTRP)[1]

This standard is issued under the fixed designation E 1118; 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 reinforced thermosetting resin pipe (RTRP) to determine structural integrity. It is applicable to lined or unlined pipe, fittings, joints, and piping systems.

1.2 This practice is applicable to pipe that is fabricated with fiberglass and carbon fiber reinforcements with reinforcing contents greater than 15 % by weight. The suitability of these procedures must be demonstrated before they are used for piping that is constructed with other reinforcing materials.

1.3 This practice is applicable to tests below pressures of 35 MPa absolute (5000 psia).

1.4 This practice is limited to pipe up to and including 0.6 m (24 in.) in diameter. Larger diameter pipe can be examined with AE, however, the procedure is outside the scope of this practice.

1.5 This practice applies to examinations of new or in-service RTRP.

1.6 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.7 *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 to 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:*

D 883 Terminology Relating to Plastics[2]

E 650 Guide for Mounting Piezoelectric Acoustic Emission Sensors[3]

E 750 Practice for Characterizing Acoustic Emission Instrumentation[3]

E 976 Guide for Determining the Reproducibility of Acoustic Emission Sensor Response[3]

E 1316 Terminology for Nondestructive Examinations[3]

2.2 *ASNT Standards:*[4]

ANSI/ASNT CP-189 Personnel Qualification and Certification in Nondestructive Testing

ASNT SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing

2.3 *Military Standards:*[5]

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification

NAS-410 Certification and Qualification of Nondestructive Test Personnel

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *component and assembly proof testing*—a program of tests on RTRP components designed to assess product quality in a manufacturer's plant, at the installation site, or when taken out of service for retesting. An assembly is a shippable unit of factory-assembled components.

3.2.2 *count value N_c*—an evaluation criterion based on the total number of AE counts. (See A2.5.)

3.2.3 *diameter to thickness ratio (d/t)*—equal to $\frac{D_o + D_i}{2t}$ where (D_o) is the outside pipe diameter, (D_i) is the inside pipe diameter, and (t) is the wall thickness, as measured in a section of straight pipe.

3.2.4 *high-amplitude threshold*—a threshold for large amplitude events. (See A2.3.)

3.2.5 *in-service systems testing*—a program of periodic tests during the lifetime of an RTRP system designed to assess its structural integrity.

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

[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.

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[2] *Annual Book of ASTM Standards,* Vol 08.01.

[3] *Annual Book of ASTM Standards,* Vol 03.03.

[4] Available from American Society for Nondestructive Testing, 1711 Arlingate Plaza, P.O. Box 28518, Columbus, OH 43228-0518.

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

3.2.7 *manufacturers qualification testing*—a comprehensive program of tests to confirm product design, performance acceptability, and fabricator capability.

3.2.8 *operating pressure*—pressure at which the RTRP normally operates. It should not exceed design pressure.

3.2.9 *qualification test pressure*—a test pressure which is set by agreement between the user, manufacturer, or test agency, or combination thereof.

3.2.10 *rated pressure*—a nonstandard term used by RTRP pipe manufacturers as an indication of the maximum operating pressure.

3.2.11 *RTRP*—Reinforced Thermosetting Resin Pipe, a tubular product containing reinforcement embedded in or surrounded by cured thermosetting resin.

3.2.12 *RTRP system*—a pipe structure assembled from various components that are bonded, threaded, layed-up, etc., into a functional unit.

3.2.13 *signal value M*—a measure of the AE signal power (energy/unit time) which is used to indicate adhesive bond failure in RTRP cemented joints. (See A2.4.)

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

3.2.15 *system proof testing*—a program of tests on an assembled RTRP system designed to assess its structural integrity prior to in-service use.

4. Summary of Practice

4.1 This practice consists of subjecting RTRP to increasing or cyclic pressure while monitoring with sensors that are sensitive to acoustic emission (transient stress waves) caused by growing flaws. Where appropriate, other types of loading may be superposed or may replace the pressure load, for example, thermal, bending, tensile, etc. 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 RTRP.

4.3 This practice provides guidelines for AE examination of RTRP within the pressure range stated in 1.2. Maximum test pressure for RTRP will be determined upon agreement among user, manufacturer, or test agency, or combination thereof. The test pressure will normally be 1.1 multiplied by the maximum operating pressure.

5. Significance and Use

5.1 The AE examination method detects damage in RTRP. The damage mechanisms detected in RTRP are as follows: resin cracking, fiber debonding, fiber pullout, fiber breakage, delamination, and bond or thread failure in assembled joints. Flaws in unstressed areas and flaws which are structurally insignificant will not generate AE.

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

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

6. Basis of Application

6.1 *Personnel Qualification*

6.1.1 If specified in the contractual agreement, personnel performing examinations to this standard shall be qualified in accordance with a nationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, MIL-STD-410, 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.

6.2 *Qualification of Nondestructive Agencies*—If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in E-543. The applicable edition of E-543 shall be specified in the contractual agreement.

6.3 *Timing of Examination*—The timing of examination shall be in accordance with paragraph 11 unless otherwise specified.

6.4 *Extent of Examination*—The extent of examination shall be in accordance with paragraph 9.4 unless otherwise specified.

6.5 *Reporting Criteria/Acceptance Criteria*—Reporting criteria for the examination results shall be in accordance with paragraph 12 unless otherwise specified. Since acceptance criteria are not specified in this standard, 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 standard and if required 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 events above the low-amplitude threshold. It shall also record events above the high-amplitude threshold as well as signal value *M* within specific frequency ranges, and have sufficient channels to localize AE sources in real time. It may incorporate (as an option) peak amplitude detection. An AE event amplitude measurement is recommended for sensitivity verification (see Annex A2). Amplitude distributions are recommended for flaw characterization. It is preferred that the AE instrumentation acquire and record count, event, amplitude, and signal value *M* 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-load shall be continuously monitored to an accuracy of ±2 % of the maximum test value.

8. Test Preparations

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

8.1.1 Protective clothing and equipment that is normally required in the area in which the test 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 against the consequences of catastrophic failure when testing, for example, flying debris and impact of escaping liquid.

8.1.4 Pneumatic testing is extremely dangerous and shall be avoided if at all possible.

8.2 *RTRP Conditioning*:

8.2.1 If the pipe has not been previously loaded, no conditioning is required.

8.2.2 If the pipe has been previously loaded, one of two methods shall be used. For both methods, the maximum operating pressure-load in the pipe since the previous examination must be known. If more than one year has elapsed since the last examination, the maximum operating pressure-load during the past year can be used. (See 11.2.3.)

8.2.2.1 Option I requires that the test shall be run from 90 up to 110 % of the maximum operating pressure-load. In this case no conditioning is required. (See Fig. 7.) If it is not possible to achieve over 100 % of the maximum operating pressure-load, Option II may be used.

8.2.2.2 Option II requires that the operating pressure-load be reduced prior to testing in accordance with the schedule shown in Table 1. In this case, the maximum pressure-load need be only 100 % of the operating pressure (see Fig. 8).

8.3 *RTRP Pressurizing-Loading*—Arrangements should be made to pressurize the RTRP to the appropriate pressure-load. Liquid is the preferred pressurizing medium. Holding pressure-load levels is a key aspect of an acoustic emission examination. Accordingly, provision shall be made for holding the pressure-load at designated check points.

8.4 *RTRP Support*—The RTRP system shall be properly supported.

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

8.6 *Noise Reduction*—Noise sources in the examination frequency and amplitude range, such as malfunctioning pumps or valves, movement of pipe on supports, or rain, must be minimized since they mask the AE signals emanating from the pipe.

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

8.8 *Instrumentation Settings*—Settings will be determined in accordance with Annex A2.

9. Sensors

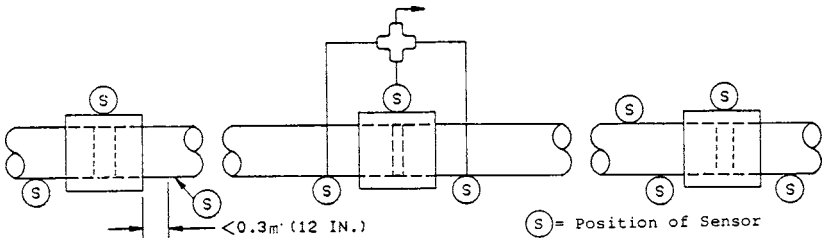
9.1 *Sensor Mounting*—Refer to Guide E 650 for additional information on sensor mounting. Location and spacing of the sensors are discussed in 9.4. Sensors shall be placed in the designated locations with a couplant interface between sensor and test article. One recommended couplant is silicone-stopcock grease. Care must be exercised to ensure 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 strips of pressure-sensitive tape, stretch fabric tape with hook and loop fastener, 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 causing loss of coupling.

9.2 *Surface Contact*—Reliable coupling between the sensor and pipe surface shall be ensured and the surface of the pipe in contact with the sensor shall be clean and free of particulate matter. Sensors should be mounted directly on the RTRP 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, inadequate sensor contact on curved surfaces, off-center sensor positioning and surface roughness at the contact area.

9.3 *Zone Location*—Several high-frequency sensors (100 to 250 kHz) are used for zone location of emission sources. Attenuation is greater at higher frequencies requiring closer spacing of sensors. Zones may be refined if events hit more than one sensor. (See Fig. 1 and Annex A3.)

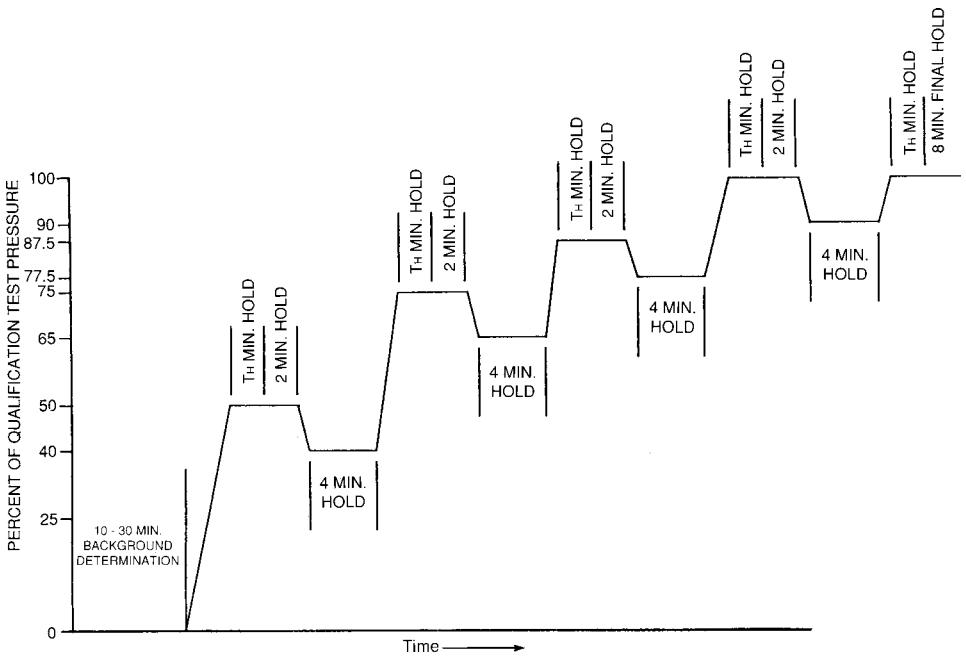
9.4 *Locations and Spacings*—Sensor locations on the RTRP are determined by the need to detect structural flaws at critical sections, for example, joints, high-stress areas, geometric discontinuities, repaired regions, and visible defects. The number of sensors and their location is based on whether full coverage or random sampling of the system is desired. For full coverage of the RTRP, excluding joints, sensor spacings of 3 m (10 ft) are usually suitable.

9.4.1 *Attenuation Characterization*—Signal propagation losses shall be determined in accordance with the following



NOTE 1—A maximum of three sensors can be connected into one channel.

FIG. 1 Typical Sensor Positioning for Zone Location



NOTE 1—Diameter to thickness ratio (d/t) ≥ 16, T_H = 2 min. Diameter to thickness ratio (d/t) < 16, T_H = 4 min.

FIG. 2 RTRP Manufacturer's Qualification Test, Pressurizing Sequence

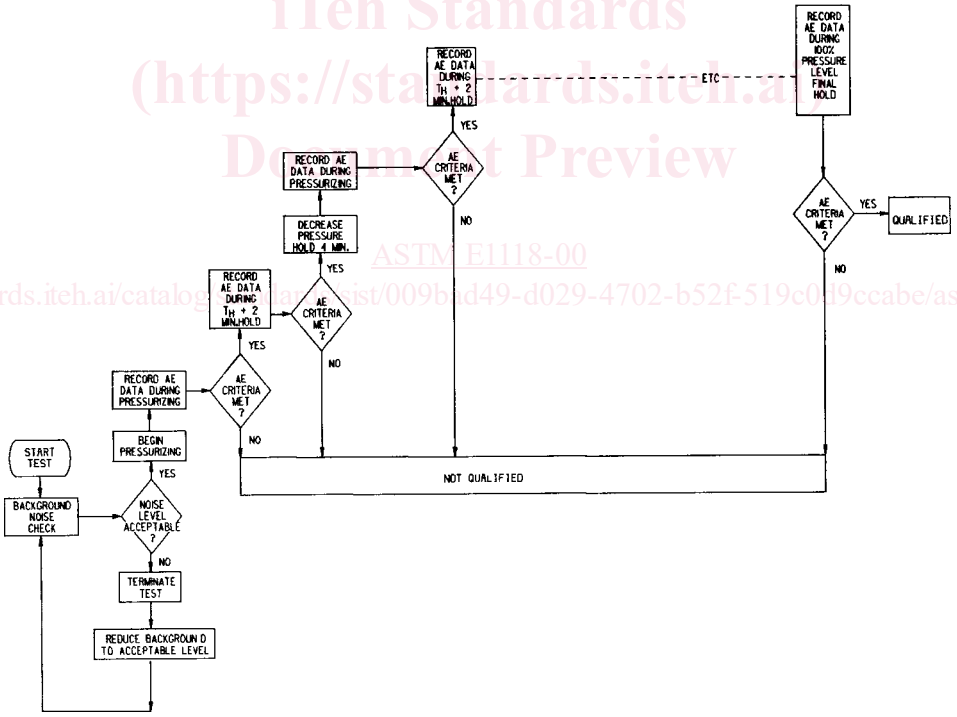
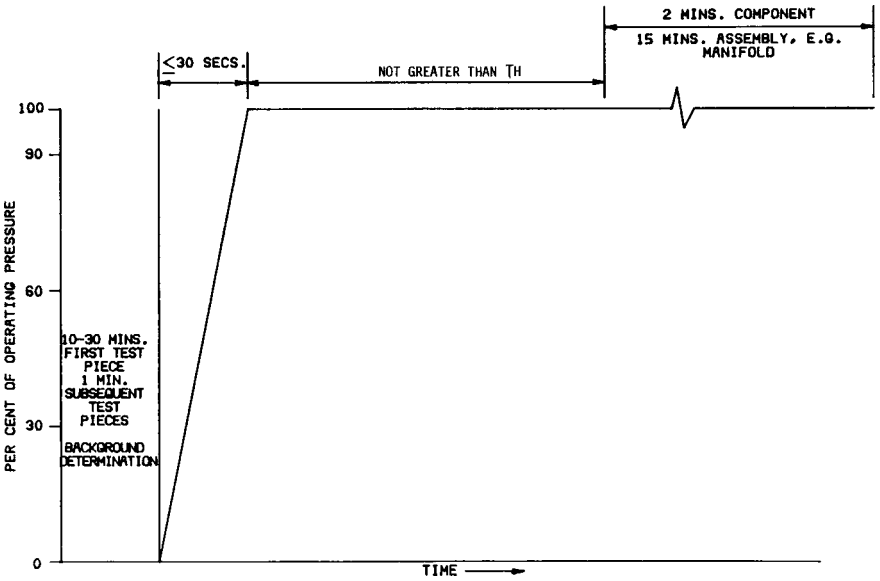


FIG. 3 AE Test Algorithm—Flow Chart, RTRP Qualification Test (see Fig. 2)

procedure. This procedure provides a relative measure of the attenuation, but may not be representative of a genuine event. It should be noted that the peak amplitude from a mechanical pencil lead break may vary with surface hardness, resin condition, cure, and test fluid. For pressure tests, the attenuation characterization shall be carried out with the pipe full of the test fluid.

9.4.1.1 Select a representative region of the RTRP. Mount an AE sensor and locate points at distances of 150 mm (6 in.) and 300 mm (12 in.) from the center of the sensor along a line parallel to the axis of the pipe. Select two additional points on the surface of the pipe at 150 mm (6 in.) and 300 mm (12 in.) along a helix line inclined 45° to the direction of the original



NOTE 1—Diameter to thickness ratio (d/t) ≥ 16, T_H = 2 min. Diameter to thickness ratio (d/t) < 16, T_H = 4 min.

FIG. 4 RTRP Component and Assembly Proof Test, Pressurizing Sequence

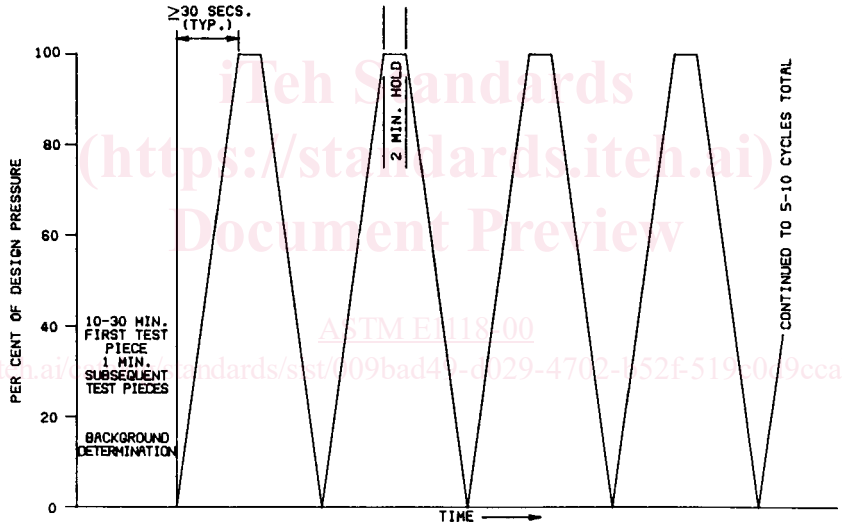


FIG. 5 RTRP Systems Proof Test, Pressurizing Sequence

points. At each of the four points, break 0.3-mm 2H leads[6] and record peak amplitude. All lead breaks shall be done at an angle of approximately 30° to the test surface with a 2.5-mm (0.1-in.) lead extension (see Guide E 976). The data shall be retained as part of the original experimental record.

9.4.2 *Sensor Location*—Severe attenuation losses occur at unreinforced adhesive joint lines and across threaded joints. Accordingly, sensors should be located on either side of such interfaces. The sensor spacing on straight sections of pipe shall be not greater than 3 × the distance at which the recorded amplitude from the attenuation characterization equals the low-amplitude threshold. The spacing distance shall be measured along the surface of the pipe.

9.4.3 Sensor zone location guidelines for the following RTRP configurations are given in Annex A3. Other configurations require an agreement among the user, manufacturer, or test agency, or combination thereof.

9.4.3.1 **Case I:** *Coupled*—Cemented or threaded joint pipe system. (The sensor on the coupling is normally required because the adhesive is highly attenuative.)

9.4.3.2 **Case II:** *Bell and Spigot*—Cemented or threaded joint pipe system.

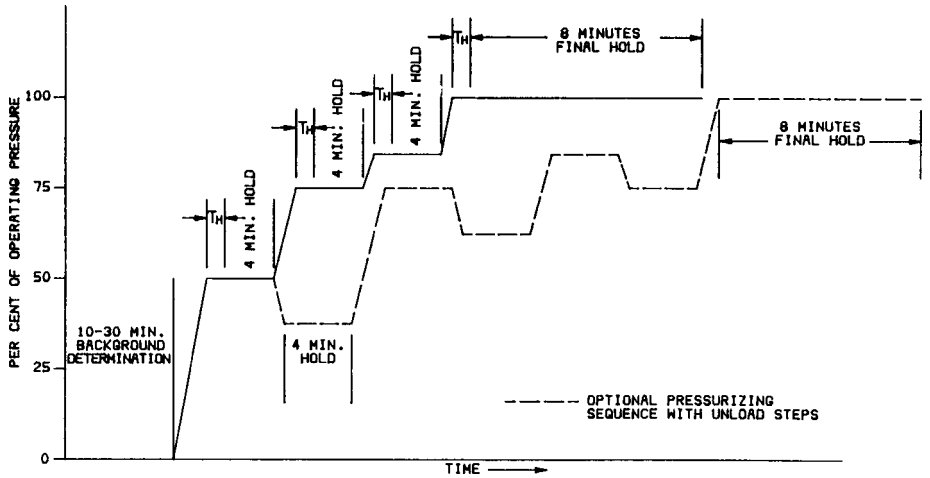
9.4.3.3 **Case III:** *Hand Lay-up*—Field fabricated secondary bond mat joint pipe system.

9.4.3.4 **Case IV:** *Flanged Joint Pipe System.*

10. Instrumentation System Performance Check

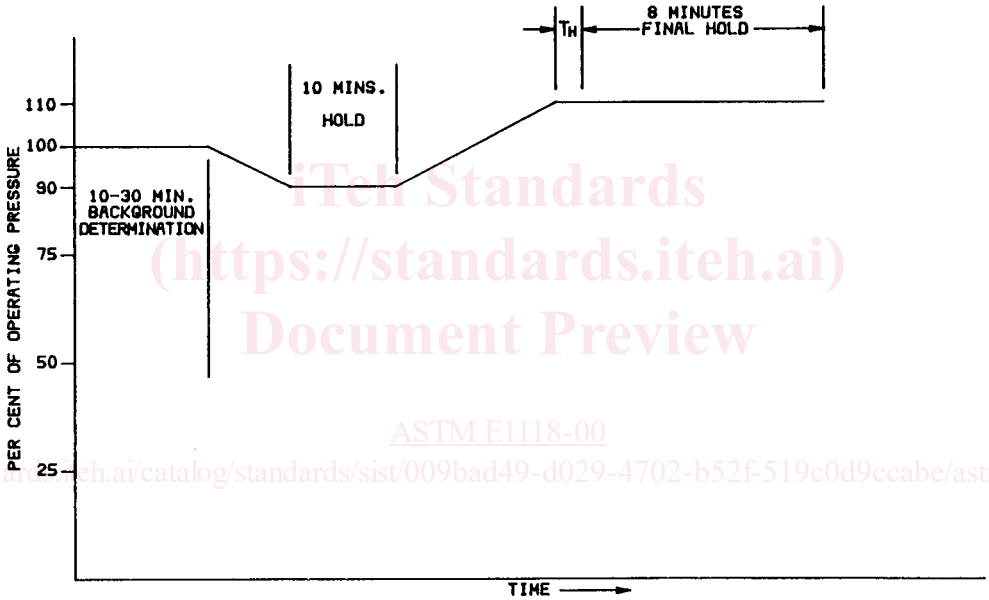
10.1 *Sensor Coupling and Circuit Continuity Verification*—Verification shall be performed following sensor mounting and

[6] Pentel 0.3 (2H) lead or its equivalent has been found satisfactory for this purpose.



NOTE 1—Diameter to thickness ratio (d/t) ≥ 16, T_H = 2 min. Diameter to thickness ratio (d/t) < 16, T_H = 4 min.

FIG. 6 RTRP Systems Proof Test, Alternate Pressurizing Sequence



NOTE 1—Diameter to thickness ratio (d/t) ≥ 16, T_H = 2 min. Diameter to thickness ratio (d/t) < 16, T_H = 4 min.

FIG. 7 RTRP System In-Service Test, Option I, Pressurizing Sequence

TABLE 1 Option II Requirements for Reduced Operating Pressure-Load Immediately Prior to Testing

Percent 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

system hookup. The peak amplitude response of each sensor-preamplifier combination to a repeatable simulated acoustic emission source (see Annex A2) should be taken prior to the examination. The peak amplitude of the simulated event generated at 150 mm (6 in.) from each sensor should not vary more than 6 dB from the average of all the sensors. Any sensor-preamplifier combination failing this check should be investigated and replaced or repaired as necessary.

10.2 *Background Noise Check*—A background noise check is required to identify and determine level of spurious signals. This is done following completion of the verification described in 10.1 and prior to pressurizing the RTRP. A recommended time period is 10 to 30 min. A low level of background noise is important for conducting an examination and is particularly important for zone location. Continuous background noise at a level above the low amplitude threshold is unacceptable and must be reduced before conducting the examination.

11. Testing Procedure

11.1 *General Guidelines*—The RTRP is subjected to programmed increasing pressure-load levels to a predetermined