Designation: ~~E1118/E1118M – 11~~ E1118/E1118M – 16

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

This standard is issued under the fixed designation E1118/E1118M; 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~~ 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 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.

1.7 *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:*[2]
D883 Terminology Relating to Plastics
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
E1106 Test Method for Primary Calibration of Acoustic Emission Sensors
E1316 Terminology for Nondestructive Examinations
E1781 Practice for Secondary Calibration of Acoustic Emission Sensors
E2075 Practice for Verifying the Consistency of AE-Sensor Response Using an Acrylic Rod
2.2 *ASNT Standards:*[3]
ANSI/ASNT CP-189 Personnel Qualification and Certification in Nondestructive Testing
ASNT SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing
2.3 *AIA Standard:*[4]
NAS-410 Certification and Qualification of Nondestructive Test Personnel

---

[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 ~~Jan. 1, 2011~~Dec. 1, 2016. Published ~~February 2011~~December 2016. Originally approved in 1986. Last previous edition approved in ~~2005~~2011 as ~~E1118 - 05.~~E1118 - 11. DOI: ~~10.1520/E1118_E1118M-11.~~10.1520/E1118_E1118M-16.

[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 The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Ln., Columbus, OH 43228-0518.

[4] Available from Aerospace Industries Association of America, Inc. (AIA), 1250 Eye St., NW, Washington, DC 20005.

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

2.4 *ISO Documents*[5]
ISO 9712 Non-destructive Testing—Qualification and Certification of NDT Personnel

3. Terminology

3.1 Complete glossaries of terms related to plastics and acoustic emission will be found in Terminologies D883 and E1316.

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 A2.6.)

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.)

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 A2.5.)

3.2.14 *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 1.3. 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] 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.

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 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, ASNT 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 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 *Timing of Examination*—The timing of examination shall be in accordance with Section 11 unless otherwise specified.

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

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

6.7 *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 E750.

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.

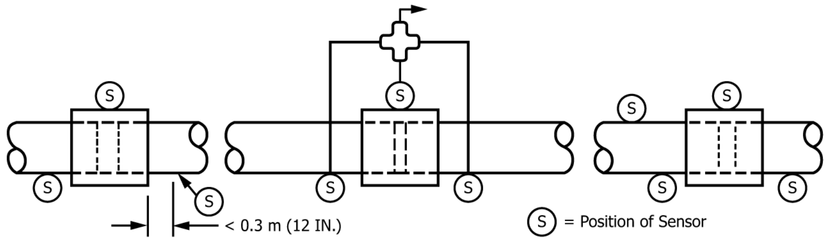
8.2.2 If the pipe has been previously loaded, one of two methods shall be used. For both methods, the maximum operating pressure-load in the pipe since the previous examination must be known. If more than one year has elapsed since the last examination, the maximum operating pressure-load during the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

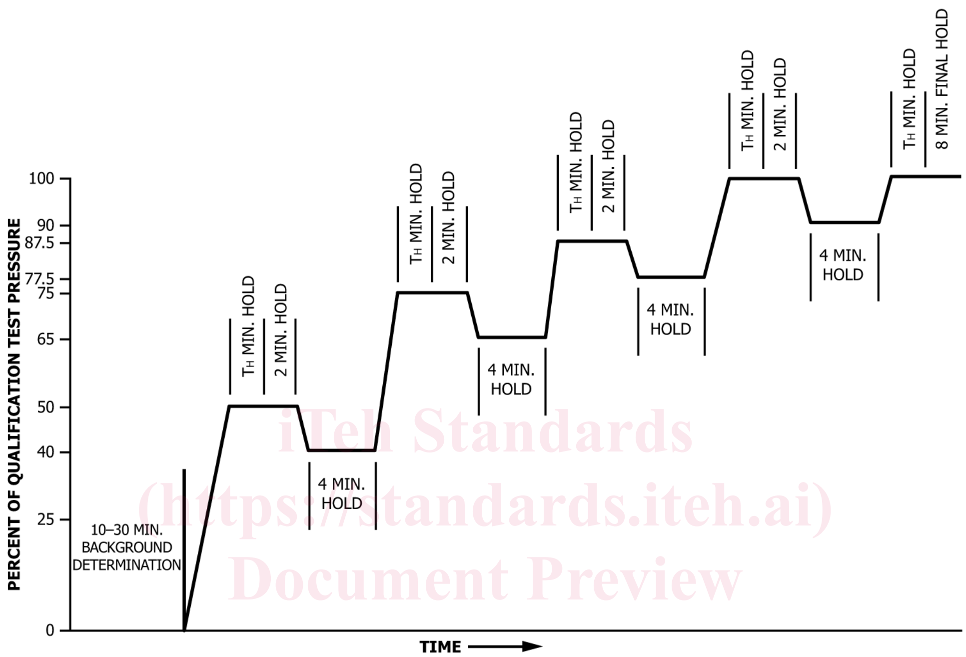
8.3 *RTRP Pressurizing-Loading*—Arrangements should be made to pressurize the RTRP to the appropriate pressure-load. Liquid is the preferred pressurizing medium. Holding pressure-load levels is a key aspect of an acoustic emission examination. Accordingly, provision shall be made for holding the pressure-load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

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



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

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 E650 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.

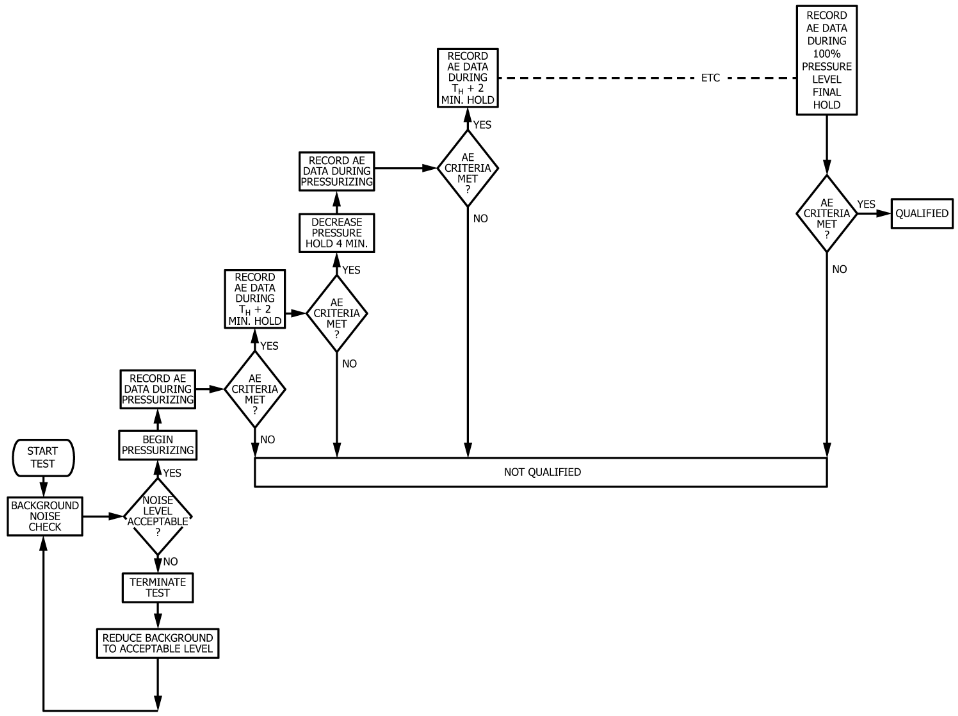
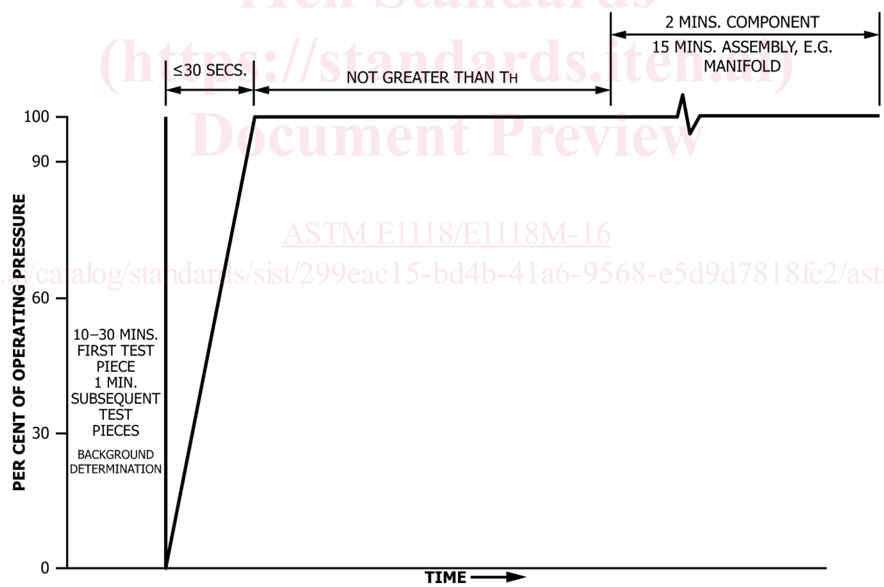


FIG. 3 AE Test Algorithm—Flow Chart, RTRP Qualification Test (see Fig. 2)



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

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 procedure. This procedure provides a relative measure of the attenuation, but may not be representative of a genuine event. It should be noted

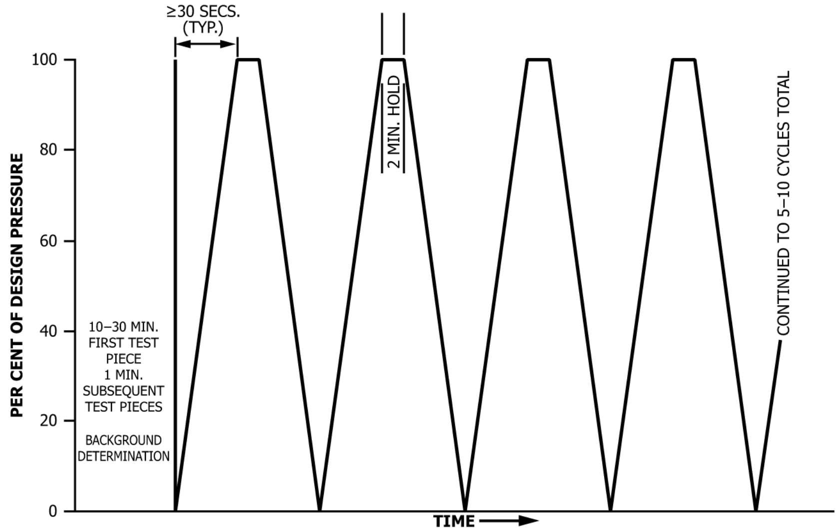
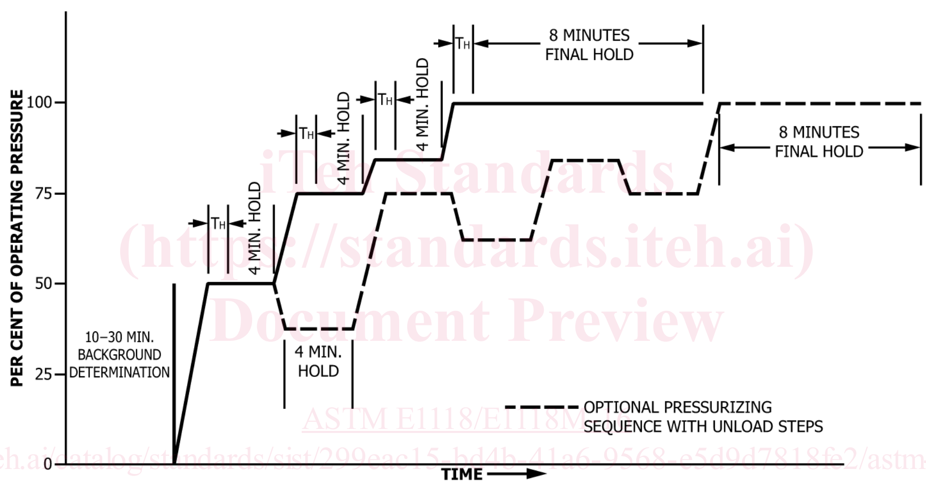


FIG. 5 RTRP Systems Proof Test, Pressurizing Sequence



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. 6 RTRP Systems Proof Test, Alternate Pressurizing Sequence

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 points. At each of the four points, break 0.3 mm [0.012 in.] 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 E976). 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.

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