Designation: F1055 – 16a

Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing[1]

This standard is issued under the fixed designation F1055; 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 specification covers electrofusion polyethylene fittings for use with outside diameter-controlled polyethylene pipe, covered by Specifications D2513, D2737, D3035, F714, F2623, F2769 and crosslinked polyethylene (PEX), covered by Specifications F876 and F2788/F2788M. Requirements for materials, workmanship, and testing performance are included. All requirements for joining PE electrofusion fittings to PE pipe shall also apply to joining PE electrofusion fittings to PEX pipe. Where applicable in this specification "pipe" shall mean "pipe" or "tubing."

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 The following safety hazards caveat pertains only to the test method portion, Section 9, of this specification: *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D638 Test Method for Tensile Properties of Plastics

D1598 Test Method for Time-to-Failure of Plastic Pipe Under Constant Internal Pressure

D1599 Test Method for Resistance to Short-Time Hydraulic Pressure of Plastic Pipe, Tubing, and Fittings

D1600 Terminology for Abbreviated Terms Relating to Plastics

D2513 Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings

D2737 Specification for Polyethylene (PE) Plastic Tubing

D3035 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

D3350 Specification for Polyethylene Plastics Pipe and Fittings Materials

F412 Terminology Relating to Plastic Piping Systems

F714 Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

F876 Specification for Crosslinked Polyethylene (PEX) Tubing

F905 Practice for Qualification of Polyethylene Saddle-Fused Joints

F1473 Test Method for Notch Tensile Test to Measure the Resistance to Slow Crack Growth of Polyethylene Pipes and Resins

F2623 Specification for Polyethylene of Raised Temperature (PE-RT) SDR 9 Tubing

F2788/F2788M Specification for Metric and Inch-sized Crosslinked Polyethylene (PEX) Pipe

F2769 Specification for Polyethylene of Raised Temperature (PE-RT) Plastic Hot and Cold-Water Tubing and Distribution Systems

2.2 *PPI Standards:*[3]

PPI TR-3 Policies and Procedures for Developing Hydrostatic Design Basis (HDB), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Rating for Thermoplastic Piping Materials or Pipe

PPI TR-4 HDB/SDB/PDB/MRS Listed Materials, PPI Listing of Hydrostatic Design Basis (HDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Rating for Thermoplastic Piping Materials or Pipe

[1] This specification is under the jurisdiction of ASTM Committee F17 on Plastic Piping Systems and is the direct responsibility of Subcommittee F17.10 on Fittings.

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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 Plastics Pipe Institute (PPI), 105 Decker Court, Suite 825, Irving, TX 75062, http://www.plasticpipe.org.

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

2.3 *ISO Standards:*[4]

ISO 13954 Plastics pipe and fittings – Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal diameter greater than or equal to 90 mm

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology F412, and abbreviations are in accordance with Terminology D1600, unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *electrofusion*—a heat fusion joining process where the heat source is an integral part of the fitting, such that when electric current is applied, heat is produced that melts and joins the plastics.

3.2.2 *fusion interface*—surface in the heat fusion process where the plastic materials of the products being joined bond together.

3.2.3 *fusion zone length*—total length of the melted material in the fitting cross-section under evaluation.

4. Materials and Manufacture

4.1 This specification covers fittings made from polyethylene compounds as defined in Specification D3350.

4.1.1 Polyethylene material compounds suitable for use in the manufacture of electrofusion fittings under this specification shall meet Specification D3350 and shall meet Specification D3350 classification and property requirements shown in Table 1 and shall have PPI TR-4 HDB and HDS listings at 73°F (23°C) and HDB listings at 140°F (60°C).

4.2 *Rework Material*—Clean rework polyethylene material of the same resin, free of any wire or contaminants generated from the fitting manufacturer's own production, may be used by the same manufacturer, as long as the fittings produced conform to the requirements of this specification.

4.3 *Heating Mechanism*—The heat mechanism shall be of materials and design not detrimental to the performance of the fitting or the pipe to which it is intended to be joined. Heating mechanisms, such as wires or materials other than polyethylene, shall not exit the fitting in an area exposed to internal pressure. Heat mechanisms shall be of a design that ensures that wire terminations are toward the outer edges of the fusion zone length and away from the pressure containing area. Examples of acceptable and unacceptable wire terminations are shown in Figs. 1-5.

4.4 *Pipe with Layers:*

4.4.1 Pipe that has an exterior layer of material for color, or UV resistance, or oxygen transmission resistance, or as a removable layer to keep the base pipe outer surface clean is acceptable when such layers comply with the applicable pipe specification. When the exterior layer is a material other than the base pipe material, complete removal of the exterior layer prior to electrofusion joining is required in order to achieve proper fusion.

4.4.2 When the exterior layer is removed, the outside diameter of the base pipe shall meet the outside diameter dimension and tolerance requirements of the applicable pipe specification.

4.4.3 *Mid-wall layer pipes*—Electrofusion fittings for pipe that has a mid-wall layer are outside of the scope of this standard. Pipe that has a mid-wall layer shall not be used to qualify fittings to this standard.

5. Performance Requirements

5.1 The following requirements are for electrofusion joints that have been joined using the manufacturer's recommended joining procedures. These requirements must be met by each electrofusion joint design, on each size and type of pipe material for which the manufacturer recommends use of his fitting. Any revisions to the electrofusion joint design or processing by the manufacturer after the initial testing requires retesting to ensure these requirements can still be met. Fittings intended for use in the distribution of natural gas or liquid petroleum gas shall also meet the requirements of Specification D2513.

5.1.1 Assemblies using PEX pipes joined with electrofusion fittings shall be limited to the HDS rating of the PE material of the fitting as per 4.1.1 with a maximum usage temperature of 140°F.

5.1.2 Assemblies using PEX pipes joined with electrofusion fittings shall not be used for distribution of natural gas or liquid petroleum gas.

[4] 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.

TABLE 1 Specification D3350 Classification Requirements of Polyethylene Electrofusion Fitting Materials

Physical Properties	Cell Classification and Properties for Polyethylene Materials	
	PE2708	PE4710
Density	2	4
Melt Index	3 or 4	4
Flexural Modulus	≥4	≥5
Tensile Strength	≥3	≥4
Slow Crack Growth Resistance (F1473)	7	7
Hydrostatic Strength Classification	3	4
Color and UV Stabilizer	C or E	C or E
HDB at 73°F (23°C), psi (MPa)	1250 (8.62)	1600 (11.03)

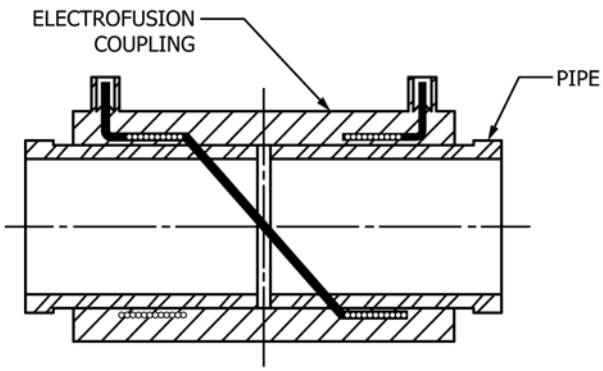

FIG. 1 Correct Wire Termination Coupling–Single Coil

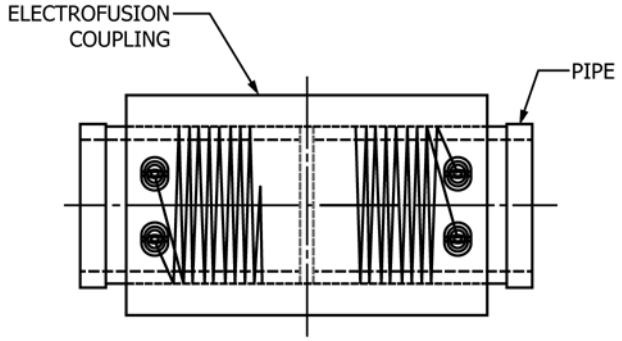

FIG. 2 Correct Wire Termination Coupling–Dual Coil

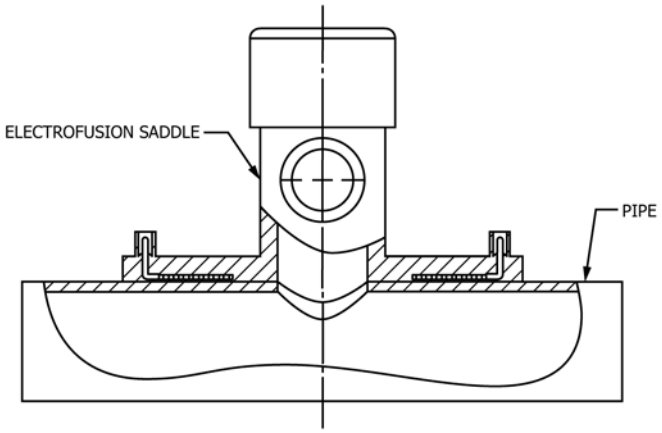

FIG. 3 Correct Wire Termination–Saddle Fitting

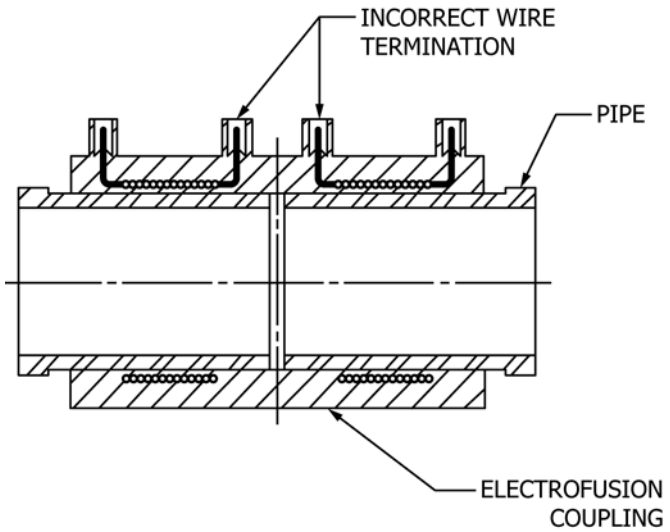

FIG. 4 Incorrect Wire Termination Coupling–Dual Coil

5.1.3 It is not required that each configuration of a fitting be tested to meet all of these qualifications (that is, 2 in. main saddle joint with multiple outlet configurations offered) as long as the electrofusion joint design is not altered in the configuration differences.

NOTE 1—It is permissible when accomplishing these tests, to do so on the highest and lowest dimension ratio of the same pipe material. If in those tests all performance requirements are met, all dimension ratios between those tested may be considered as having met the requirements. These tests do not have to cover the full range of dimension ratios available, only the dimension ratio range on which the manufacturer recommends his fitting be used.

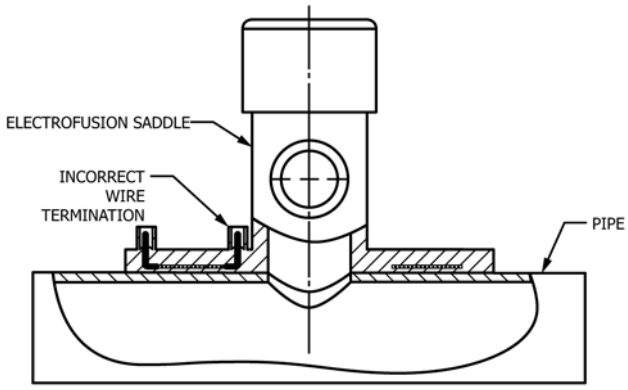

FIG. 5 Incorrect Wire Termination Saddle–Single Coil

5.2 *Pressure Requirements:*

5.2.1 *Minimum Hydraulic Burst Pressure*—The fitting and fused joint shall not fail when tested in accordance with 9.1. The minimum hydraulic burst pressure at 73°F (23°C) of the test specimen shall not be less than that required to produce the minimum fiber stress in the pipe as required by the controlling pipe standard for the type of pipe used in the test. In no case shall the minimum hydraulic burst pressure be less than that required to produce 2520 psi (17.4 MPa) fiber stress in the pipe for medium density PE (density cell 2) and 2900 psi (20 MPa) fiber stress in the pipe for high density PE (density cell 3 or 4) test specimens when tested in accordance with 9.1. The test equipment, procedures, and failures definitions shall be as specified in Test Method D1599.

5.2.2 *Sustained Pressure*—The fitting and fused joint shall not fail when tested in accordance with 9.2. The test pressure, minimum time-to-failure, and test temperature shall be as required by the controlling pipe standard for the type of pipe used in the test. Where the controlling pipe standard requires testing at multiple temperatures, sustained pressure testing shall only be performed at the highest test temperature, not to exceed 180°F (82°C). If a pipe standard is not specified, or does not contain test requirements, the test pressure, minimum time-to-failure and test temperature shall be as shown in Table 2.

5.3 *Tensile Strength Requirements (Coupling Type Joints Only)*—The fitting or the pipe to fitting joint made on pipe shall not fail when tested in accordance with 9.3. Specimens shall be subjected to a tensile stress that causes the pipe to yield to an elongation no less than 25 % or causes the pipe to break outside the joint area. Tensile tests must be made on specimens as joined, not on straps cut from the specimen. Yielding must be measured only in the pipe, independent of the fitting or joint.

5.3.1 Equipment needed to conduct full scale tensile tests for sizes 8 IPS and larger is not readily available; therefore, an optional alternative to full-scale tensile tests for coupling-type joints 8 IPS and larger is included as mandatory information in Annex A2. The tests performed in Annex A2 qualifies the fitting design in lieu of tensile strength requirements testing of

TABLE 2 Supplemental Sustained Pressure Test Requirements for the Pipe Material Being Tested

Condition	Test Temperature °F (°C)[A]	PE2408, PE2706, PE2708		PE3408, PE3608, PE3708, PE3710, PE4708, PE4710	
		Test Pressure Hoop Stress psi[B] (kPa)[A]	Minimum Average Time Before Failure Hours	Test Pressure Hoop Stress psi[B] (kPa)[A]	Minimum Average Time Before Failure Hours
1	176 (80)	670 (4620)	170	750 (5170)	200
2	176 (80)	650 (4480)	340	730 (5020)	400
3	176 (80)	630 (4345)	510	705 (4870)	600
4	176 (80)	610 (4210)	680	685 (4715)	800
5	176 (80)	590 (4070)	850	660 (4565)	1000
6	176 (80)	580 (4000)	1000	640 (4415)	1200

[A]Test temperature tolerance ± 4 °F (± 2 °C). Test pressure tolerance ± 5 psi (± 35 kPa); test pressure hoop stress values are rounded to the nearest 5 psi or 5 kPa. Table 2 conditions are based on PE validation requirements per PPI TR-3 with Condition 6 being 85% of Condition 1 hoop stress and six times greater minimum average time before failure. Conditions 2 through 5 are linear stress and time interpolations between Condition 1 and 6. The intent of multiple conditions is to maintain equivalent performance criteria, but provide for retest in the event of a ductile failure. The test pressure hoop stress levels for Conditions 2-5 are linear interpolations for arbitrarily chosen time increments. An equivalent performance requirement, however, may be determined by arbitrarily choosing a test pressure hoop stress between Conditions 1 and 6 and linearly interpolating the minimum average time before failure. For example for PE4710 material, at 670 psi test pressure hoop stress, the minimum average time before failure would be 927 hours (200 + (750 – 670) · ((1200 – 200) / (750 – 640)) = 927.
[B]Calculate internal test pressure in accordance with:

$$P = \frac{2S}{\left(\frac{Do}{t} - 1\right)}$$

where:

P = test pressure, psig (kPa)
S = test pressure hoop stress, psi (kPa)
Do = measured outside pipe diameter, in. (mm)
t = measured minimum pipe wall thickness, in (mm)

5.3 and the joint crush test portion of 5.5. All other performance requirements in Section 5 shall be satisfied by testing to the requirements using the methods described in Section 9.

5.4 *Impact Resistance (Saddle Type Joints Only)*—The joint made on the specimen shall not fail when impacted with a force sufficient to break the body or other portion of the specimen. Tests of 500 ft·lbf or higher impact with no failures noted shall be considered as a "pass" impact test. The device for testing and the methods shall be as defined in Practice F905.

5.5 *Joint Integrity Tests—(Couplings and Saddle Type Joints)*—The joint made on the specimen shall meet the requirements in 9.4 and 9.5 of this specification, when tested in accordance with 9.4.

5.5.1 Equipment needed to perform crush testing to the procedure described in 9.4.1 for sizes 8 IPS and larger is not readily available, or can be hazardous to operate safely; therefore, an optional alternative to crush tests for coupling-type joints 8 IPS and larger is included as mandatory information in Annex A2. Tests performed in Annex A2 qualify the fitting design in lieu of the joint crush test portion of 9.4.1. All other performance requirements in Section 5 and 9.4 shall be satisfied by testing to the requirements using the methods described in 9.

6. Dimensions, Mass, and Permissible Variations

6.1 Dimension and tolerances of electrofusion fittings must be such that heat fusion is possible to outside diameter (OD) controlled PE pipes such as those listed in Specifications D2513, D2737, D3035, F714, F2623 and, F2769 and PEX pipes listed in Specifications F876 and F2788/F2788M, such that the joints will satisfy the performance requirements in Section 5.

6.2 Because of the varying designs for electrofusion fittings, the actual spread of dimensions may be quite different from manufacturer to manufacturer. A table of dimensions and tolerances encompassing these differences would be meaningless and without value and, therefore, is omitted from this specification.

6.3 The manufacturer shall furnish to the user the electrical resistance, critical dimensions, and tolerances of his fittings. This information must include at least the following dimensions and tolerances:

6.3.1 Coupling inside diameter,
6.3.2 Temperature joining limits, and
6.3.3 Operating pressure of the fitting.

NOTE 2—There are other items that fall beyond the scope of this specification which would be of interest to the user for proper application of the fittings and is recommended as additional information to be furnished. A few of these are: (*1*) maximum pipe out of round allowed at joint area; (*2*) minimum/maximum pipe SDR capability of the fitting, and (*3*) for saddles intended for use on a live main, the maximum allowable line pressure when making the joint.

7. Workmanship, Finish, and Appearance

7.1 The manufacture of these fittings shall be in accordance with good commercial practice so as to produce fittings meeting the requirements of this specification.

7.2 The fittings shall be homogeneous throughout, except where a heating coil or electrical connectors are incorporated, and free of cracks, holes, foreign inclusions, or injurious defects such as gouges, dents, cuts, etc. The fittings shall be as uniform as commercially practicable in opacity, density, and other physical properties. Any heating coils, connecting cables, connectors, and related electrical power source shall be designed to prevent electrical shock to the user.

8. Specimen Preparation

8.1 *Conditioning:*

8.1.1 Unless otherwise specified, condition the specimens (pipe and fittings) prior to joining at the minimum pipe temperature allowable for fusion as recommended by the manufacturer, for not less than 16 h and make the fusion joint at that temperature for those tests where conditioning is required.

8.1.2 Unless otherwise specified, condition the specimens (pipe and fittings) prior to joining at the maximum pipe temperature allowable for fusion as recommended by the manufacturer, for not less than 16 h and make the fusion joint at that temperature for those tests where conditioning is required.

8.2 *Test Conditions*—Conduct the tests at the Standard Laboratory Temperature of 73 ± 3.6°F (23 ± 2°C) unless otherwise specified.

8.3 *Preparation of Specimens for Testing:*

8.3.1 Prepare test specimens so that the minimum length of unreinforced pipe on one side of any fitting is equal to three times the diameter of the pipe, but in no case less than 12 in. (304 mm). It is permissible to test multiple fittings together provided they are separated by a minimum distance equal to three times the diameter of the pipe, but in no case less than 12 in. (304 mm).

8.3.2 Fuse all fitting outlets with the appropriate size pipe in accordance with the manufacturer's recommended procedures.

8.3.2.1 When pipe with an exterior layer of material other than the base pipe material are prepared for electrofusion joining, preparation prior to joining shall completely remove the exterior layer, and preparation shall comply with the pipe manufacturer's instructions.

(1) There shall be no damage to the base pipe after removal of the layer(s) has taken place.

(2) After removal of the exterior layer, the base pipe shall comply with the outside diameter dimension and tolerance requirements of the applicable tubing or pipe specification.

NOTE 3—The pipe manufacturer's instructions for electrofusion joining of exterior layer pipe preparation should include information so that complete removal of the exterior layer may be visually confirmed.

8.3.3 All saddle fusion joint specimens conditioned as in 8.1.2 and destined for quick burst testing as in 9.1 and sustained pressure testing as in 9.2, are to be joined with the pipe at no less than maximum allowable operating pressure of the pipe system or fitting, whichever is lowest, when being prepared for those tests. The pipe should be left under pressure for a time period not less than recommended by the manufacturer for cooling in the field prior to disturbing the joint. Saddle joint specimens destined for mechanical/destructive type tests such as impact as in 5.4 or crush tests as in 9.4, or specimens conditioned for cold temperature joining as in 8.1.1, may be made on unpressured pipe specimens.

9. Test Methods

9.1 *Minimum Hydraulic Burst Pressure Test:*

9.1.1 Select four fittings at random and prepare specimens in accordance with Section 8. From the four specimens, condition two specimens each in accordance with 8.1.1 and 8.1.2.

9.1.2 Test the specimens in accordance with Test Method D1599.

9.1.3 Failure of the fitting or joint shall constitute specimen failure.

9.1.4 Failure of any one of the four specimens shall constitute failure of the test. Failure of one of the four specimens tested is cause for retest of four additional specimens, joined at the failed specimens joining temperature. Failure of any of these four additional specimens constitutes a failure of the test.

9.2 *Sustained Pressure Test:*

9.2.1 Select four fittings at random and prepare specimens in accordance with Section 8 of this specification. From the four specimens, condition two specimens each in accordance with 8.1.1 and 8.1.2.

9.2.2 Test the specimens in accordance with Test Method D1598. The assemblies are to be subjected to pipe fiber stresses and minimum test periods in accordance with the controlling pipe standards requirements for sustained pressure test. Joint specimens shall not fail within these time periods. Any failures within these time periods must be of the pipe, independent of the fitting or joint and must be of a" brittle" type pipe failure, not "ductile." If ductile pipe failures occur, reduce the pressure of the test and repeat until the required results or pipe brittle failures are achieved. If test conditions are not specified by the controlling pipe standard, the requirements of Table 2 shall be used for the pipe material type being tested with the electrofusion fitting.

9.2.3 Failure of the fitting or joint shall constitute specimen failure.

9.2.4 Failure of any one of the four specimens shall constitute failure of the test. Failure of one of the four specimens tested is cause for retest of four additional specimens, joined at the failed-specimens-joining temperature. Failure of any of these four additional specimens constitutes a failure of the test.

9.3 *Tensile Strength Test (Coupling Type Joints Only):*

9.3.1 Select four fittings at random and prepare specimens in accordance with Section 8 with the exception that it is permissible, on pipe sizes above 4 in. (102 mm) IPS, if limits of tensile machine will not allow 25 % elongation with pipe specimens of three-pipe diameters, to test with free pipe lengths of 20 in. (304-mm) minimum. From the four specimens, condition two specimens each in accordance with 8.1.1 and 8.1.2.

9.3.2 Test the specimens using the apparatus of Test Method D638. Test at a pull rate of 0.20 in. (5.0 mm) per min, ±25 %.

9.3.3 Failure of the fitting or joint as defined in 5.3, shall constitute specimen failure.

9.3.4 Failure of any one of the four specimens shall constitute failure of the test. Failure of one of the four specimens tested is cause for retest of four additional specimens, joined at the failed specimens joining temperature. Failure of any of these four additional specimens constitutes a failure of the test.

9.4 *Joint Integrity Tests*—Illustrations of joint crush tests for socket type joints and saddles are offered in 9.4.1 and 9.4.2 as test methods that are useful as an evaluation of bonding strength between the pipe and fitting. Alternately, the fusion evaluation test (FET) offered in 9.4.3 and 9.4.4 may be used in lieu of the crush test. Similar test evaluations as specified in the contract or purchase order and as agreed upon by the purchaser and manufacturer are of equal value in performing such evaluations and may be substituted with such agreement.

9.4.1 *Joint Crush Test (Coupling Type Joints Only):*

9.4.1.1 Select four fittings at random and prepare specimens in accordance with Section 8. From the four specimens, condition two specimens each in accordance with 8.1.1 and 8.1.2 (Note 4).

NOTE 4—It is permissible to utilize in joint integrity testing, specimens from the quick-burst tests conducted in 9.1 after visually determining that neither the joint area nor the pipe segment to be crushed was a part of the failure mode in the quick-burst test.

9.4.1.2 Slit socket joints longitudinally as illustrated in Fig. 6 as near the centerline of the pipe as practical. Pipe lengths extending out of the socket may be cut back to a minimum of 3 in. (76 mm) for ease of placing in a vise.

9.4.1.3 Place each specimen half in a vise such that the outermost wire of coil is within 1.250 ± 0.125 in. (32 ± 3 mm) of vise jaws, with the jaws closing only on the pipe portion of the specimen (Fig. 7).

9.4.1.4 Tighten the jaws of the vise on the pipe until the inner walls of the pipe meet (Fig. 8). Repeat crush test on both halves and each end of specimen, at all ends, where a joint exists.

9.4.1.5 Separation of the fitting from the pipe at the fusion interface constitutes a failure of the test. Some minor separation at the outer limits of the fusion heat source up to 15 % of the fusion length may be seen. This does not constitute a failure. Ductile failure in the pipe, fitting, or the wire insulation material, is acceptable as long as the bond interface remains intact.

9.4.1.6 Failure of any one of the four specimens shall constitute failure of the test and is cause for retest of four additional fittings, joined at the same temperature as the failed specimens. Failure of any of these four additional specimens constitutes a failure of the test.

9.4.2 *Saddle Type Joint Crush Test (Not Full-Wrap Design):*

9.4.2.1 Select four fittings at random and prepare specimens in accordance with Section 8. From the four specimens, condition two specimens each in accordance with 8.1.1 and 8.1.2 (see 9.4).

9.4.2.2 Pipe lengths extending from saddle joint may be cut back clear up to the outer edges of the saddle for convenience

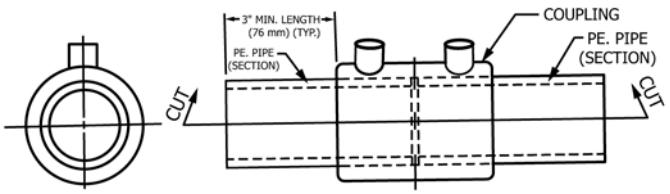

FIG. 6 Preparation of Coupling Specimen for Crush Test

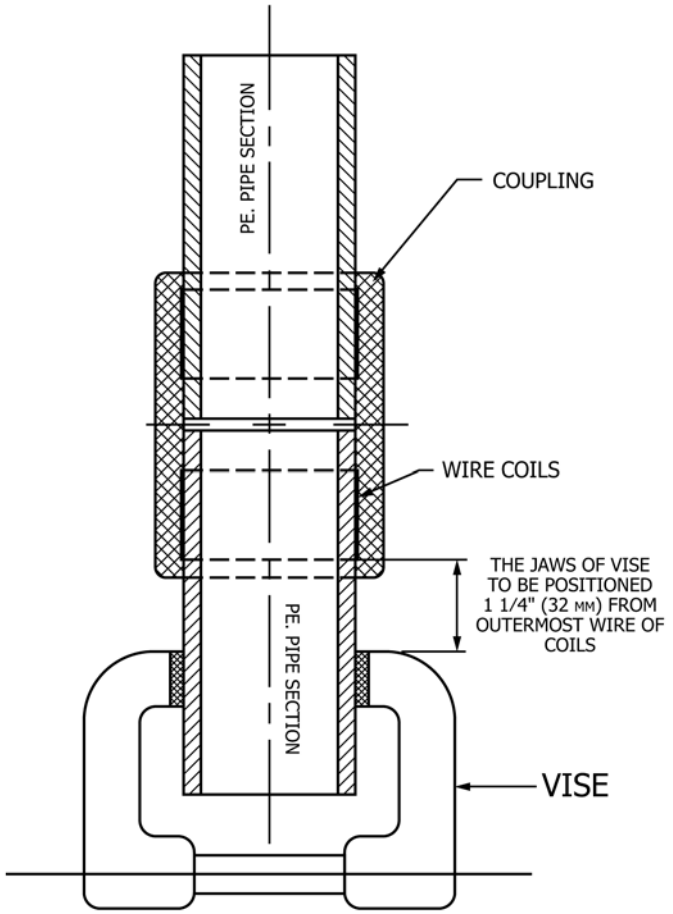

FIG. 7 Coupling Crush Test Arrangement

of handling, if desired, however, it is not necessary. The length of the pipe extending beyond the saddle is not important to this test (Fig. 9).

9.4.2.3 Place the specimen in vise jaws as shown in Fig. 10, such that vise jaws are within ½ in. of saddle bottom and the jaws will close only on the pipe portion of the specimen. Saddle designs incorporating a bottom half saddle will need the bottom half removed for this test. Saddle designs incorporating a full-wrap single piece saddle are to be tested as in 9.4 socket type joints (Fig. 7 and Fig. 8).

9.4.2.4 Tighten the jaws of the vise on the pipe until the inner walls of the pipe meet (Fig. 11).

9.4.2.5 Separation of the fitting from the pipe at the fusion interface constitutes a failure of the test. Some minor separation at the outer limits of the fusion heat source up to 15 % of the fusion length may be seen. This does not constitute a failure. Ductile failure in the pipe, fitting, or the wire insulation material, is acceptable as long as the bond interface remains intact.

9.4.2.6 Failure of any one of the four specimens shall constitute failure of the test and is cause for retest of four additional fittings, joined at the same temperature as the failed specimens. Failure of any of these four additional specimens constitutes a failure of the test.

9.4.3 *Fusion Evaluation Test (FET) of Sockets:*

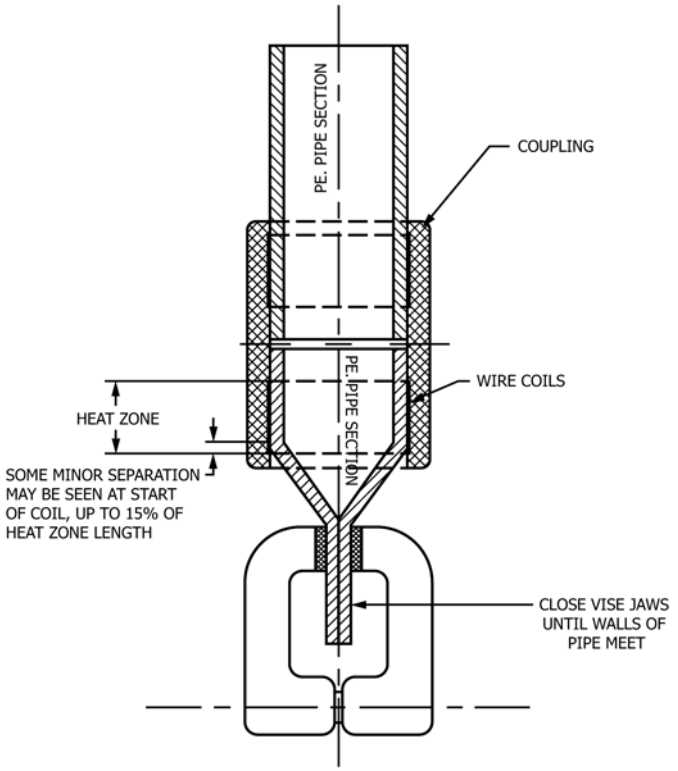

FIG. 8 Coupling Crush Test

9.4.3.1 Select four fittings at random and prepare specimens in accordance with Section 8. From the four specimens, condition two specimens each in accordance with 8.1.1 and 8.1.2.

9.4.3.2 A band saw with a locking guide and a blade restricted to cutting plastic is recommended for obtaining the FET samples. Slit the socket in the order of cuts as illustrated in Fig. 12. First, radially cut the socket in half along the centerline of the joint. Pipe extending from the fittings may be cut back to about 1 in. from the fitting edge. Cut FET specimens approximately 1⁄16 in. wide from each joint half. A minimum of four FET strips shall be cut from one half of the socket and spaced approximately 90° apart.

9.4.3.3 Grip an FET specimen in a vise or clamping device as shown in Fig. 13 so that the bond line between the pipe and fitting is at least 1⁄16 in. from the edges of the clamping device. Flex the specimen four times 90° in both directions. Pliers may be used in lieu of a vise as long as the entire length of the fusion is flexed.

9.4.3.4 Separation of the specimen along the bond line constitutes failure of the specimen. Some minor separation at the outer limits of the fusion heat source may be seen or there may be voids between wires. This does not constitute failure as long as the voids do not exceed the limits of 9.5. Ductile failure in the pipe, fitting, or the wire insulation material is acceptable as long as the bond interface remains intact.

9.4.3.5 Failure of any one of the four joints shall constitute failure of the test and is cause for retest using four additional fittings joined at the same conditions as the failed joint specimens. Failure of any of these four additional joint specimens constitutes a failure in the test.

9.4.4 *Fusion Evaluation Test of Saddle Type Joints (Not Full-Wrap Design):*

9.4.4.1 Select four fittings at random and prepare specimens in accordance with Section 8. From the four specimens, condition two specimens each in accordance with 8.1.1 and 8.1.2.

9.4.4.2 A band saw with a locking guide and a blade restricted to cutting plastic is recommended for obtaining the FET samples. Remove the stack from the fitting and cut the bottom portion of the pipe from the test piece. Cut the saddle in half in the transverse direction and then cut each half again in the longitudinal direction as shown in Fig. 14. Cut FET specimens approximately 1⁄16 in. wide through the fusion base of the saddle fitting. These cuts must be both longitudinal and transverse using two diagonal quarters for transverse direction and the two remaining quarters for the longitudinal direction.

9.4.4.3 Inspect the fusion area for any discontinuities. Follow the instructions in 9.4.3.3 to test the FET samples.

9.4.4.4 Separation of the specimen along the bond line constitutes failure of the specimen. Some minor separation at the outer limits of the fusion heat source may be seen or there may be voids between wires. This does not constitute failure as long as the voids do not exceed the limits of 9.5. Ductile failure in the pipe, fitting, or the wire insulation material is acceptable as long as the bond interface remains intact.

9.4.4.5 Failure of any one of the four joints shall constitute failure of the test and is cause for retest using four additional fittings, joined at the same conditions as the failed joint specimens. Failure of any of these four additional joint specimens constitutes a failure in the test.

9.5 *Evaluation for Voids*—When dissecting electrofusion joints for the integrity tests in 9.4, or any reason, voids at or near the fusion interface may be exposed. The voids, should they be present, are a phenomenon of the electrofusion process, due to trapped air and shrinking during the cooling process after the joint is made. If detected, such voids are considered acceptable only if round or elliptical in shape, with no sharp corners allowed and if they meet the limitations of 9.5.1 through 9.5.3.

9.5.1 Voids that do not exceed 10 % of the fusion zone length in size are acceptable. (See Fig. 15.)

9.5.2 Multiple voids, if present, are acceptable if the combined void sizes do not exceed 20 % of the fusion zone length. (See Fig. 15.)

9.5.3 If voids are exposed, additional longitudinal cuts should be made to ensure that the void does not follow a diametric path which connects to the pressure-containing area of the joint. (See Fig. 16.)

NOTE 5—Some voids in electrofusion fitting joints may be due to the natural phenomenon described in 9.5. It is also possible the voids can be produced by not following proper fusion procedures. If voids are detected, one should ensure that all procedures were followed in making the joint.

10. Product Marking

10.1 Fittings shall be marked with the following:

10.1.1 Manufacturer's name or trademark,

10.1.2 Material designation (for example, PE2708, PE4710, etc.),

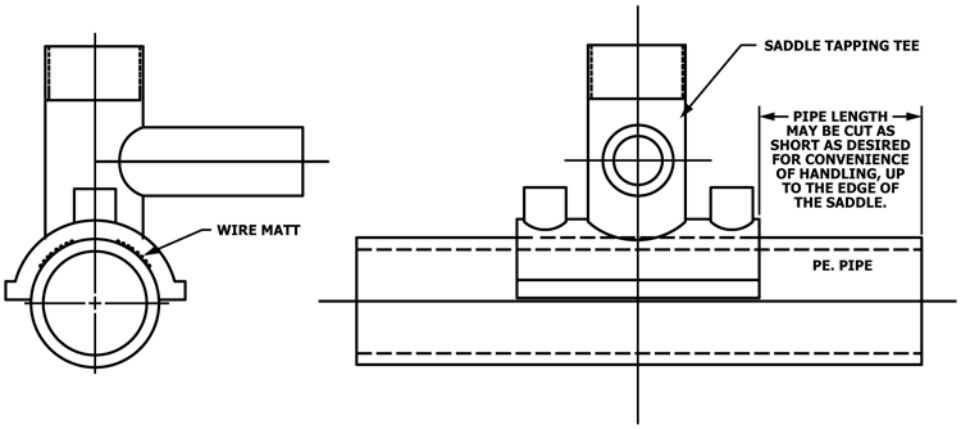

FIG. 9 Preparation of Saddle Specimen for Crush Test

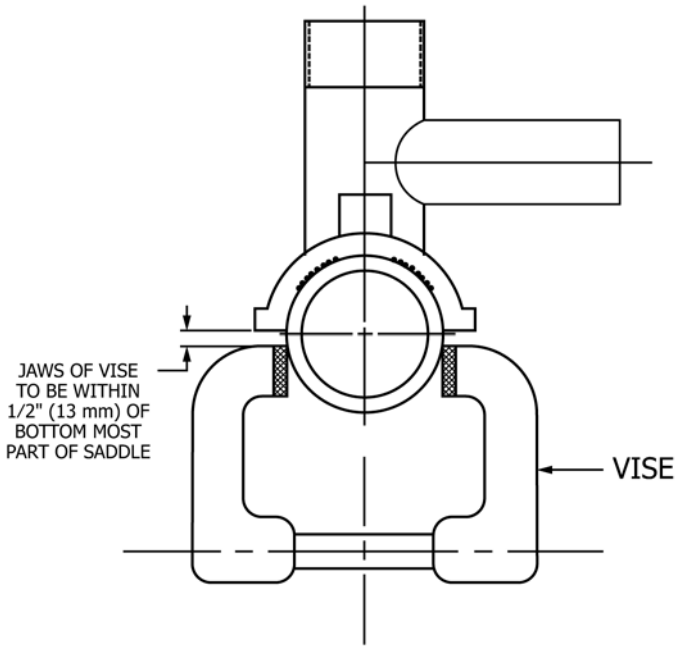

FIG. 10 Saddle Fitting Crush Test Before Crush

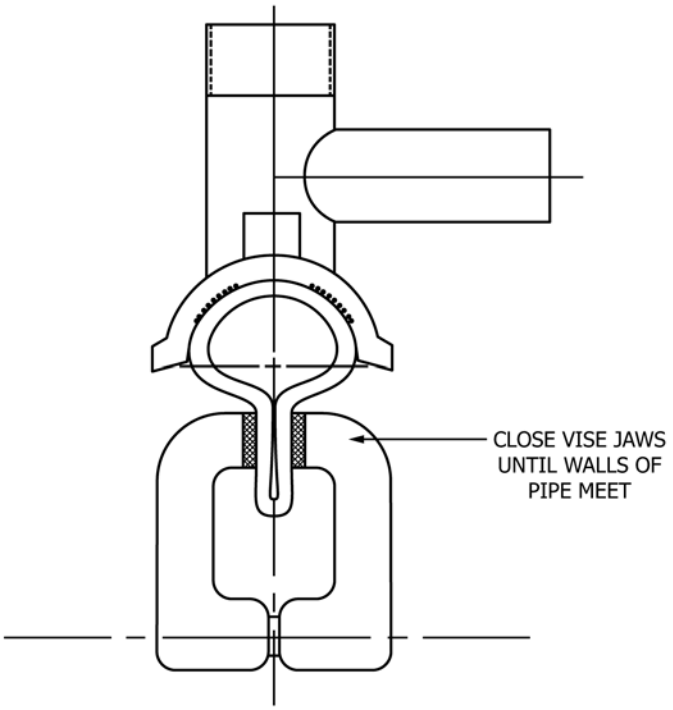

FIG. 11 Saddle Fitting Crush Test After Crush

NOTE 6—Earlier editions of ASTM F1055, as well as related piping standards, included PE material designations PE2306, PE2406, PE3406, and PE3408. Changes to Specification D3350 and PPI TR-3 led to changes in thermoplastic material designation codes, resulting in material designation PE2406 being superseded by material designation PE2708. Similarly, PE3408 was superseded by material designations PE3708, PE3710, PE4708, and PE4710. Recognizing that a period of time is necessary for the dissemination of information and to update specifications and literature, during the transitional period, product markings that include both older and newer material designations, for example PE3408/PE4710, may occur.

10.1.3 For fittings intended for transporting potable water, the seal of approval of an accredited laboratory, for fittings complying with Specification D2513 and intended for gas distribution, the word "gas" or if space does not permit, the letter "G,"

10.1.4 Size, followed by "IPS" or "CTS" designation,

10.1.5 This designation ASTM F1055,

10.1.6 The fittings shall bear an appropriate code number that will assure identification on the fittings as to date of production and resin formulas used in the production of said fittings. The manufacturer shall maintain such additional records as are necessary to confirm identification of all coded fittings, and

10.1.7 Where the size of the fitting does not allow complete marking, identification marking may be omitted in the following sequence: ASTM designation number, and material designation.

10.2 All required markings shall be legible and so applied as to remain legible under normal handling and installation practices. If indentation is used, it shall be demonstrated that these marks have no effect on the long term strength of the fitting.

11. Quality Assurance

11.1 When the product is marked with this designation, ASTM F1055 the manufacturer affirms that the product was

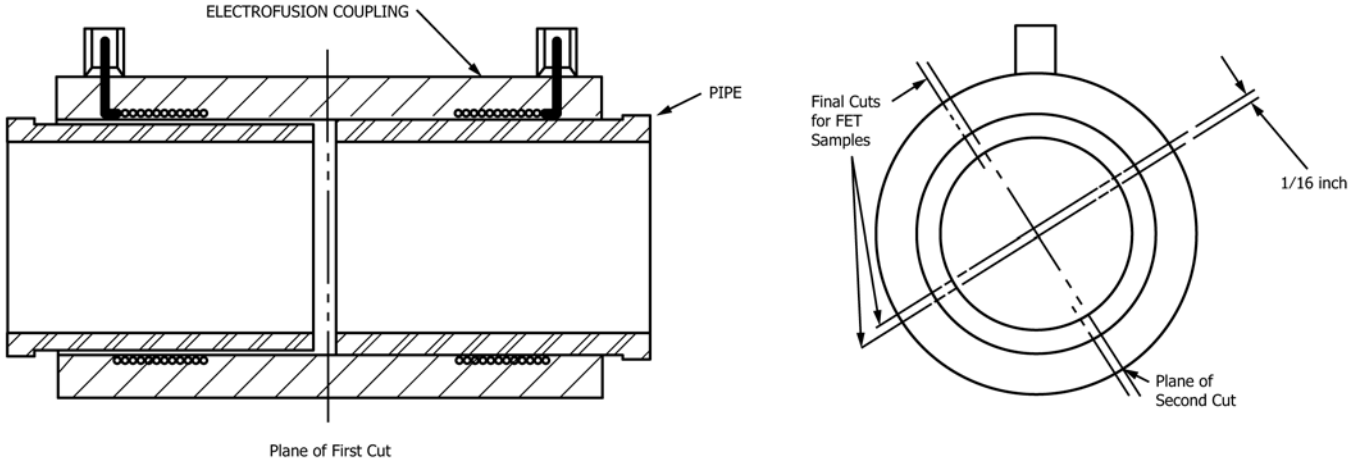

FIG. 12 Recommended Procedure for Cutting FET Strip From Coupling

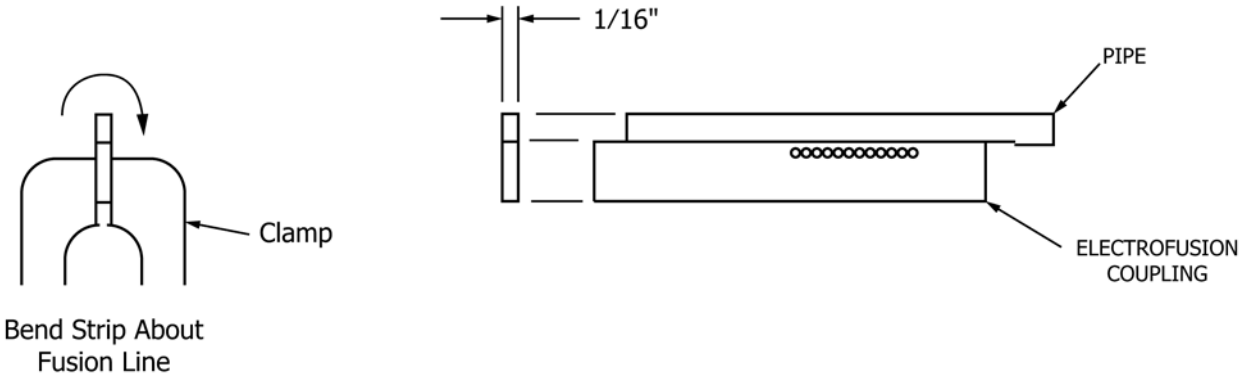

FIG. 13 Strip for FET Bend Test

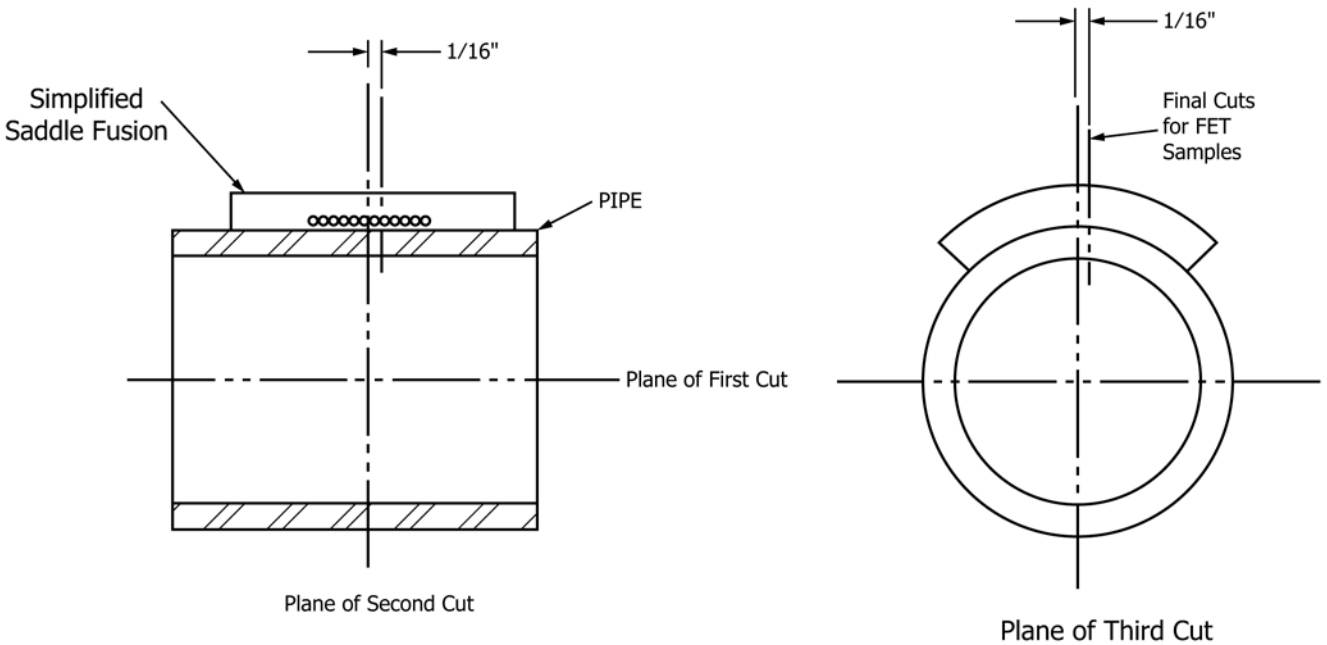

FIG. 14 Procedure for Cutting FET Strips from a Saddle

manufactured, inspected, sampled, and tested in accordance with this specification and has been found to meet the requirements of this specification.

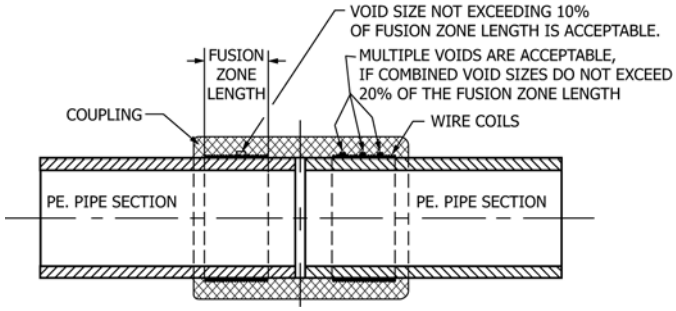

FIG. 15 Coupling Fusion Assembly With Possible Void Characteristics

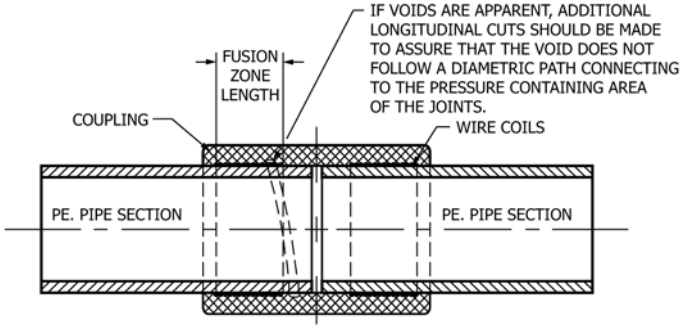

FIG. 16 Coupling Fusion Assembly—Further Examination Guidance

12. Keywords

12.1 crosslinked polyethylene; electrofusion; fittings; joining; polyethylene; PEX

ANNEXES

(Mandatory Information)

A1. IN-PLANT QUALITY CONTROL PROGRAM FOR ELECTROFUSION FITTINGS

A1.1 *Introduction:*

A1.1.1 Use the following in-plant quality control program, covering material and performance requirements in manufacture to provide reasonable assurance that the product meets the requirements of this specification and normally anticipated field performance requirements.

A1.2 *Fittings Tests:*

A1.2.1 Conduct the fittings tests at the frequencies indicated as follows:

NOTE A1.1—When any failure to meet the requirements of this specification occurs, make additional tests to ascertain those fittings that are acceptable, back to the last acceptable ones. Those that do not meet the requirements must be rejected.

A1.2.2 Dimensions of fusion area with heating element in place:

A1.2.2.1 *Socket Diameters*—Immediately proceeding production start up, then once per h, or one out of ten fittings, whichever is less frequent.

A1.2.2.2 *Saddle Sizes*—Main sizes and branching outlet sizes, immediately proceeding production start up, then once per h, or one out of ten fittings, whichever is less frequent.

A1.2.2.3 *Heating Element Resistance* —Immediately proceeding production start up, then once per h, or one out of ten fittings, whichever is less frequent.

A1.2.3 *Molding or Extrusion Quality*—Make the following tests on each cavity in the mold or each extrusion line being used. Test at the start of each production run, whenever production conditions have changed or when the resin lot has changed, but not less than once per 500 fittings thereafter.

A1.2.3.1 *Voids in Part*—Inspect for voids in the fitting by means of X-ray or dissection of the fitting in 0.25-in. (6-mm) wide strips.

A1.2.3.2 *Molding Knit Line Strength*—Test by one of the following tests, or other suitable tests:

(1) By crushing a fitting or a portion of a fitting in a manner that applies load in a direction normal to the knit line.

(2) By performing an apparent tensile strength test of a ring cut from a fitting with the load oriented normal to the knit line.

(3) By performing a burst test of the fitting in accordance with Test Method D1599.

NOTE A1.2—Separation in the knit line of any of these tests constitutes a failure of the test.

A2. RESISTANCE TO AXIAL LOAD TESTS FOR ELECTROFUSION COUPLINGS SIZES 8 IPS AND LARGER

A2.1 Introduction:

A2.1.1 In lieu of full scale tensile tests required to the method described in 9.3 and crush tests required to the method described in 9.4.1 for coupling type connections in sizes 8 IPS and larger, the tests in A2.2 shall be conducted. These tests are used as an optional method to evaluate the resistance to axial load of a fused joint as an alternative to full scale tensile tests and crush tests. All other performance requirements in Section 5 shall be satisfied by testing to the requirements using the methods described in Section 9.

A2.1.2 Short-term resistance to axial load by hydrostatic pressure testing is useful to evaluate fused coupling-to-pipe assemblies for resistance to failure in the coupling fusion, structure, or both due to axial loading. Axial loading for this test is achieved by hydraulic force from internal pressure exerted on the specimen end closures. At a constant internal pressure the force on the end closures and resulting tensile stress in the fused assembly remains constant, therefore shortening of the assembly due to expansion from Poisson effect is not a significant factor for consideration in this test. The test is conducted at an internal pressure that is 25% above the minimum required burst yield pressure of the pipe used in the test. The pipe in the test assembly is prevented from bursting by minimizing any exposed un-reinforced pipe, except that necessary for assembly and end closures. The axial forces generated within the fused assembly due to the internal pressure exceed 70% of that needed to yield and permanently deform the pipe when subjected to full scale axial load.

A2.1.3 *The Peel Test method is similar in principle to ISO 13954—Peel decohesion test for polyethylene (PE) electrofusion assemblies of nominal diameter greater than or equal to 90 mm*, however, the direction of applied loading, rate of loading, specimen fixturing, and the number of specimens required per fitting size for this specification is either not included in, or is significantly different from the ISO test method. The rate of loading used in this specification is the same rate as required for a full-scale tensile test used in 9.3.2 of this specification. The direction of the applied load is oriented so that it shall be applied from the inside of the socket outward, in order to use the thickest available cross-sectional wall for fixture strength and to apply stress in the same direction as would be applied by internal pressure in actual service. The number of specimens tested, and the location from which the specimens are taken ensures a sampling of approximately 20% of the total fused area from any given quadrant of the fused assembly.

A2.2 Fitting Tests

A2.2.1 *Short-term resistance to axial load by pressure test (Coupling Type Joints Only - ≥8 IPS)*—When tested in accordance with A2.4.1, the specimen shall not fail the short-term resistance to pressure test. Leakage or rupture through the fusion joint, or fitting, or pipe constitutes failure of the test. Leakage at flanges or other pressure connections is permitted, provided that the test pressure can be maintained for the duration of the test. Rupture of the pipe, independent of the fusion joint or fitting, constitutes an incomplete test and that specimen shall be replaced with a new specimen.

A2.2.2 *Peel Test (Coupling Type Joints Only - ≥8 IPS)*—When tested in accordance with A2.4.2 the specimens shall exhibit ductile failure over a minimum of 70% of the total fused surface area tested. The fusion length (Lf) shall be

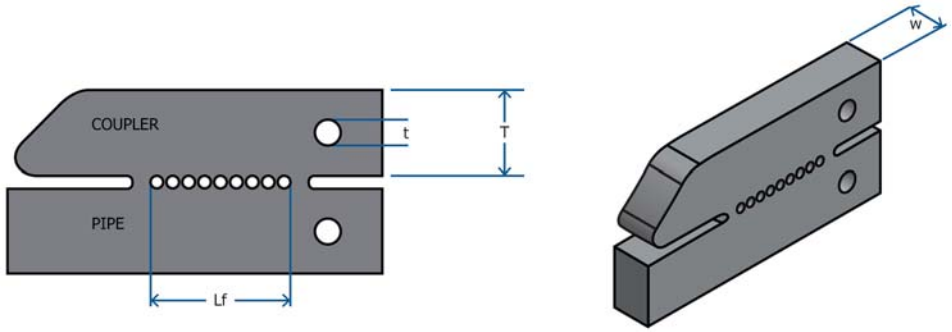

FIG. A2.1 Peel Test Strap

defined as the distance between the first and last wire of the heating coil, as shown in Fig. A2.1, except that the measurement shall be made before fusion of the specimen. Some minor separation at the outer limits of the fusion heat source, up to 15 % of the fusion length, may be seen. This does not constitute a failure. Ductile failure in the pipe, fitting, or the polyethylene material between the wires, is acceptable provided the fusion bond interface remains intact.

A2.3 Specimen Preparation

A2.3.1 *Short-term resistance to axial load by pressure test (Coupling Type Joints Only - ≥8 IPS)*—Select four fittings at random. Condition and prepare specimens in accordance with Section 8, except that the minimum length of unreinforced pipe on any side of the fitting shall be as short as possible, with length allowance only for closure and pressure connection, but in no case longer than 12 in. (304mm). Multiple fittings shall not be tested together. From the four specimens, condition and fuse two specimens each for the minimum and maximum recommended installation temperature in accordance with 8.1.1 and 8.1.2.

A2.3.2 *Peel Test (Coupling Type Joints Only - ≥8 IPS)*—Select four fittings at random. From the four specimens condition and fuse two specimens each at the minimum and maximum recommended installation temperature in accordance with 8.1.1 and 8.1.2.

A2.3.2.1 Prepare test specimens so that the minimum length of unreinforced pipe is at least the same length as the fitting end. It is permissible to cut the pipe length flush with end of the fitting.

A2.3.2.2 Cut the assembly in half at the center of the coupling, perpendicular to the pipe. From the two halves, cut the fusion joint into longitudinal straps as shown in Fig. A2.1. The strap width (W) shall be 0.75 in.s + 0.125 / -0 (19 mm +3.2 / 0). The number of straps cut from each fusion joint shall be as shown in Table A2.1. The intervals around the circumference of the fusion joint from which each strap is to be cut shall be as shown in Table A2.1.

A2.3.2.3 Drill holes through the pipe and fitting sections of each strap as shown in Fig. A2.1. The drilled holes shall be located at mid-wall (½ T). The hole location may be adjusted as needed to increase thickness and prevent tear-through of the bolt or rod. The drilled hole diameter (t) shall be ⅓ the thickness of the coupling (T) as shown in Fig. A2.1. The drilled holes are used for insertion of rods or bolts for attachment of the peeling connectors as shown in Fig. A2.2.

TABLE A2.1 Number of Specimens per Fusion Joint

Pipe Nominal Size (inches)	Pipe Nominal Size (mm)	Test Specimens Per Fitting Socket	Interval Per Specimen Cut (degrees)
8	225	8	45
10	250	8	45
12	315	12	30
14	355	12	30
16	400	16	22.5
18	450	16	22.5
20	500	16	22.5
22	560	20	18
24	630	20	18
26	650	24	15
28	700	24	15
30	750	24	15
34	800	28	12.75
36	900	32	11.25
42	1000	36	10
48	1200	40	9
54	1300	48	7.5

A2.4 Test Procedure

A2.4.1 *Short-term resistance to axial load by pressure test (Coupling Type Joints Only - ≥8 IPS):*

A2.4.1.1 Conduct the tests at the Standard Laboratory Temperature of 23°C (73.4 ± 3.6°F). Fill the test the specimen with water and test using an apparatus capable of introducing the required internal gauge pressure for minimum required test period. The apparatus described in Test Method D1598 or Test Method D1599 are suitable for this test.

A2.4.1.2 Pressurize the specimen as rapidly as possible to a test pressure at least equal to 125% of the minimum burst pressure of the pipe being used in the test. Maintain the test pressure for a period of not less than 5 min.

A2.4.1.3 Failure of the fitting or joint by rupture or leakage shall constitute specimen failure.

A2.4.1.4 Failure of any one of the four specimens shall constitute failure of the test. Failure of one of the four specimens tested is cause for retest of four additional specimens, joined at the failed specimen's joining temperature. Failure of any of these four additional specimens constitutes failure of the test.

A2.4.1.5 Leakage at flanges or other closures, independent of the fitting or fused joint, is permitted and does not constitute failure of the test as long as the internal test pressure can be maintained for the duration of the test period and does not fall below the required test pressure.

A2.4.1.6 Rupture of the pipe, independent of the fitting or fused joint, does not constitute failure of the test. Rupture of the pipe requires testing of an additional specimen joined at the same joining temperature as the ruptured specimen.

A2.4.2 *Peel Test (Coupling Type Joints Only - ≥8 IPS):*

A2.4.2.1 Conduct the tests at the Standard Laboratory Temperature of 23 ± 2°C (73.4 ± 3.6°F). Test the specimens using the apparatus of Test Method D638. Insert a bolt or rod through the drilled holes and connect to the cross-heads of the test apparatus using a cable or wire rope capable of withstanding the pull force as shown in Fig. A2.2.

A2.4.2.2 Apply a load on the peeling connectors in a manner that causes the two halves to separate at a rate of 0.20 in. (5.0 mm) per minute ±25%. The peeling direction shall be applied from the inside of the socket joint outwards. If failure occurs at a drilled hole for attachment of the peeling connector(s), reduce the size the drilled hole and rod diameter and re-test using a specimen cut immediately adjacent to the failed specimen location from the same fused joint.

A2.4.2.3 Passing results of the test shall be ductile failure of the polyethylene material between the wires or ductile tearing through the pipe or fitting material in the fusion joint as shown in Fig. A2.3, and Fig. A2.4.

A2.4.2.4 Brittle separation or lack of bonding of more than 30 % of the total length of the fusion zone length within any of

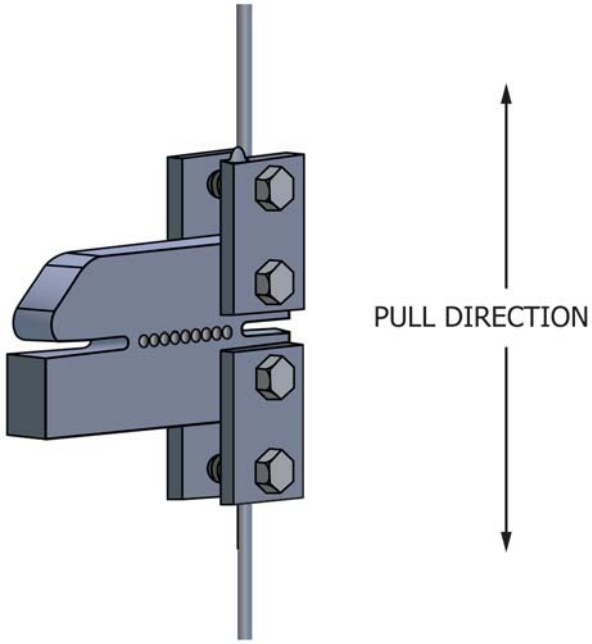

FIG. A2.2 Pull Force

FIG. A2.3 Ductile Failure in Pipe-Passing Result

FIG. A2.4 Ductile Failure between Wires-Passing Result

the specimens, as shown in figure Fig. A2.5, shall constitute failure of the test. The fusion zone length for the purpose of this test is defined as the length of fusion between the innermost and outermost wires of the fusion coil. Failure of one of the

FIG. A2.5 Brittle Separation of Fusion Zone-Failing Result

specimens tested is cause for retest of the entire set (from Table A2.1) of specimens from four additional fused joints, joined at the failed specimen's joining temperature. Failure of any one of these additional specimens constitutes a failure of the test.

SUMMARY OF CHANGES

Committee F17 has identified the location of selected changes to this standard since the last issue (F1055–16) that may impact the use of this standard.

(1) Added Specifications F2623 and F2769 to 1.1 and 2.1.
(2) Revised 4.4, 6.1 and 8.3.2.1.
(3) Deleted 4.5.

Committee F17 has identified the location of selected changes to this standard since the last issue (F1055–15) that may impact the use of this standard.

(1) Added 2.3 reference to ISO 13954.
(2) Added 5.3.1 and 5.5.1.
(3) Revised 9.3 and 9.4.1.
(4) Added Annex A2, new Fig. A2.1, Fig. A2.2, Fig. A2.3, Fig. A2.4, Fig. A2.5 and Table A2.1.