Proposed Revision of:

Thermoplastic Piping Systems

ASME Standards for Nonmetallic Pressure Piping Systems

Draft Date 6/2020
Rationale: This proposed change in the MRTPS (chapter 8) moves hydrostatic testing (current section 8-4.4) out of the Fabrication, Assembly, and Erection (section 8.4) where it does not belong, and moves it into the Inspection, Examination, Testing (section 8.5) of the chapter.

8-4.4 Hydrostatic Test

(a) Test Fluid

The test fluid shall be water unless there is a possibility of damage due to freezing or adverse effects of solvent on the piping or the process. The selection of an alternative fluid shall consider flammability, toxicity, and chemical compatibility with the MRTPS, as well as the consequences of a pipe system failure during hydrotest.

(b) Test Pressure

(1) The hydrostatic test pressure at every point in the MRTPS shall not exceed the allowable test pressure specified in the standards or material specifications for the pertinent components of the piping system.

(2) The test pressure shall be taken into consideration when defining the test pressure.

(c) Test Duration

The duration of the hydrostatic test pressure of the MRTPS, excluding the conditioning and stabilizing time, shall be a minimum of 30 minutes.

(d) Test Attest

A test record shall be completed of each MRTPS test and shall, at minimum, include the following:

- Identification of the piping system tested
- Date of test
- Test fluid
- Test pressure
- Test duration
- Test temperature
- The pressure test date
- Certification of results by the inspector
- Minimum limitations and instrumentation location

8-5 EXAMINATION, INSPECTION, AND TESTING

Examination, inspection, and testing shall follow the manufacturer’s recommendations in addition to the requirements of this standard.

This section distinguishes between examination and inspection.

Examination applies to quality control functions performed by the MRTPS manufacturer, fabricator, or erector. Reference to this standard to an examiner is to a person who performs quality control examinations.

Inspection applies to functions performed by the owner, the owner’s inspector, or the owner’s delegatee. Reference to this standard to the “Inspector” are to the owner’s inspector or the inspector’s delegate.

Inspection shall not relieve the manufacturer, the fabricator, or the owner of the responsibility for

- providing written instructions for the inspector to follow
- preparing and equipping the inspectors with the tools and equipment necessary to perform the required examinations

8-5.2 Examination

8-5.2.1 Examination at the Manufacturer’s Works

The manufacturer of the MRTPS components shall examine the manufactured components at the manufacturer’s location to ensure the components comply with the design, quality, and marking requirements of ASME Code.

8-5.2.2 Examination at the Worksites

8-5.2.2.1 Examination of Incoming Material

The pipes, fittings, and accessories shall be examined prior to the use in the construction of the piping system to ensure the correct material has been delivered and no damage has occurred during transit and handling. Any damaged items shall be replaced.
8-5.2.2.2 In-Process Examination

(a) The erection activities shall be examined to ensure the piping system is installed in accordance with the design specifications and in such a way as to avoid any damage that may affect the long-term integrity of the piping system.

(b) Wherever the installation methodology allows, the following items, as a minimum, shall be examined during the piping system erection:
   (1) pipes, fittings, and accessories to ensure no damage
   (2) trench preparation as per the MRTPS manufacturer’s recommendations
   (3) pipe deployment to verify absence of kinks and damages
   (4) joining of couplings and fittings
   (5) application of corrosion-protective measures at metallic fittings, if applicable

8-5.2.2.3 Prehydrotest Examination. Upon completion of the erection activities, prior to backfilling and subsequent hydrostatic testing, the piping system shall be examined to ensure that:
(a) no damage is present
(b) adequate support and restraint are provided for the MRTPS and adjoining equipment
Backfill shall be performed in a manner that does not damage the installed piping system.

8-5.3 Inspection

Inspection should be performed at each examination milestone outlined in para 8-5.2. At a minimum, inspection should be performed at the following stages:

(a) completion of the piping system erection
(b) prior to backfilling of the piping system
(c) random checks during the hydrostatic testing of the piping system

8-5.4 Testing

8-5.4.1 Required Testing. After completion of the piping system erection and prior to operation, each piping system shall be hydrostatically tested as per para 8-5.4.2 to ensure tightness.

8-5.4.2 Limits of Tested Piping

(a) Equipment not included in the scope of the hydrostatic test shall be either disconnected from the piping system or isolated by blinds or other means during the test. A valve may be used provided the valve (including its closure mechanism) is suitable for the test pressure.
(b) Piping components and subassemblies may be tested either separately or as assembled piping.
(c) Flanged joints used to connect piping components and subassemblies that have previously been tested, and flanged joints at which a blank or blind is used to isolate equipment or other piping during a test, are not required to be leak tested.

8-5.4.3 Preparation for Hydrostatic Testing. Prior to the hydrostatic testing, MRTPS intended for buried applications shall be covered with soil, with the joints left exposed.
Proposal: to remove the term qualified life from 2 instances it appears in the MRTPS chapter of NM.1. The removal of 8-3.2.1.(c) is due to the fact that it does not address metallic-reinforced MRTPS, appears to be redundant to point (b), and 8-3.7 addresses the basis for maximum temperature for a nominal temperature rating.

Rationale: this term “qualified life” has no accepted meaning in the industry and was insisted up by a member of the committee no longer in the industry.

Original revisions are in RED. Recirculation revisions are in GREEN

Specific Proposal

<table>
<thead>
<tr>
<th>Original</th>
<th>Proposed:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8-3.2.1 Static Pressure Considerations</strong>&lt;br&gt;(a) The MAOP of the piping system shall comply with eq. (8-3-1):&lt;br&gt;MAOP NPR (8-3-1)&lt;br&gt;where MAOP = maximum allowable operating pressure, kPa (psig)&lt;br&gt;NPR = nominal pressure rating of the MRTPS, kPa (psig)&lt;br&gt;(b) For both metallic-reinforced MRTPS and nonmetallic-reinforced MRTPS, the NPR shall be as defined and established by API 15S.&lt;br&gt;(c) For nonmetallic-reinforced MRTPS, the NPR shall be determined at the maximum qualified temperature and qualified life.</td>
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<td><strong>8-3.10 Temperature Fluctuations</strong>&lt;br&gt;(a) Temperature fluctuations, including their magnitude and frequency, shall be considered during the design of the piping system.&lt;br&gt;(b) Temperature variations outside the range of the minimum allowable operating temperature and the MAOT shall be proven by qualification testing not to adversely affect the performance of the MRTPS.</td>
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<td><strong>8-3.12 Fittings and Joints</strong>&lt;br&gt;(a) The jointing system to be used as part of the MRTPS shall have been proven by performance testing and qualification, as per API 15S, to be equal or superior in performance to the pipe being joined.</td>
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</table>
Record 19-2179

The purpose of this revision is to correct the column labels for the “dry” and “saturated” weights and to round the metric units to provide the same number of significant figures for the metric units as the USC units from which they were taken in the PPI document.

Existing Table B-4.2.1-1 (For information only, numbers in strike through to be replaced with the table below)

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**Table B-4.2.1-1 Typical Soil Unit Weight**

<table>
<thead>
<tr>
<th>Soil</th>
<th>Unit Weight, kg/m³ (lb/ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry</td>
</tr>
<tr>
<td>Typical backfill</td>
<td>1920 (120)</td>
</tr>
<tr>
<td>Sands and gravels</td>
<td>1890 to 2400 (118 to 150)</td>
</tr>
<tr>
<td>Silts and clays</td>
<td>1390 to 2100 (87 to 131)</td>
</tr>
<tr>
<td>Glacial till</td>
<td>2090.42 to 2402.77 (131 to 150)</td>
</tr>
<tr>
<td>Crushed rock</td>
<td>1906.20 to 2194.53 (119 to 137)</td>
</tr>
<tr>
<td>Organic silts and clays</td>
<td>1297.50 to 1794.07 (81 to 112)</td>
</tr>
</tbody>
</table>

**GENERAL NOTE:** Values are from the PPI Handbook of Polyethylene Pipe, Chapter 6.

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Proposed revision to Table B-4.2.1-1 (but maintain the current formatting).

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**Table B-4.2.1-1 Typical Soil Unit Weight**

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<td>Glacial till</td>
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<tr>
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<tr>
<td>Organic silts and clays</td>
<td>1300 to 1790 (81 to 112)</td>
</tr>
</tbody>
</table>

**GENERAL NOTE:** Values are from the PPI Handbook of Polyethylene Pipe, Chapter 6.
Figure 2-3.2.2-1 Nomenclature for 90-deg Mitered Elbows

(a) Constant O.D., Five Segment, Reinforced Mitered Elbow [Note (1)]

(b) Constant I.D., Five Segment, Reinforced Mitered Elbow [Note (2)]

GENERAL NOTE: $\alpha_{eh} = 22.5$ deg max; $\theta$ = angle of miter cut, deg. See para. 2-3.2.4 for definitions of other terms.

NOTES:
(1) This design has a reduced I.D. A thicker wall pipe shall be used for reinforcement.
(2) This design has approximately the same I.D. as the pipe connecting to this fitting. An oversize pipe shall be used for the fabricated segments.

<table>
<thead>
<tr>
<th>Table 2-3.2.2-2 Design Factor (DF)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fitting Description</strong></td>
</tr>
<tr>
<td>PVC Schedule 40</td>
</tr>
<tr>
<td>Straight pipe</td>
</tr>
<tr>
<td>Molded fittings, solvent weld</td>
</tr>
<tr>
<td>Molded fittings, threaded (threads are actually Sch. 80)</td>
</tr>
<tr>
<td>PVC Schedule 80</td>
</tr>
<tr>
<td>Straight pipe</td>
</tr>
<tr>
<td>Molded fittings, solvent weld</td>
</tr>
<tr>
<td>Molded fittings, threaded</td>
</tr>
<tr>
<td>CPVC Schedule 40</td>
</tr>
<tr>
<td>Straight pipe</td>
</tr>
<tr>
<td>Molded fittings, solvent weld</td>
</tr>
<tr>
<td>CPVC Schedule 80</td>
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<td>Molded fittings, solvent weld</td>
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<tr>
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<td>ABS Pressure Piping Components</td>
</tr>
<tr>
<td>Straight pipe</td>
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<td>Molded fittings, solvent weld</td>
</tr>
<tr>
<td>Molded fittings, threaded</td>
</tr>
</tbody>
</table>
Table 2.3.2.3 Pressure Rating (PR) at 23°C (73°F)

<table>
<thead>
<tr>
<th>Fitting Description</th>
<th>PR, MPa (psi)</th>
<th>Reference Specification</th>
</tr>
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<tbody>
<tr>
<td>PVC Schedule 40</td>
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<td></td>
</tr>
<tr>
<td>Molded unions</td>
<td>1.034 (150)</td>
<td>ASME SF-1970</td>
</tr>
<tr>
<td>Molded wyes</td>
<td>1.034 (150)</td>
<td>ASME SF-1970</td>
</tr>
<tr>
<td>PVC Schedule 80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Molded flange adapters</td>
<td>1.034 (150)</td>
<td>ASME SF-1970</td>
</tr>
<tr>
<td>Molded unions</td>
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<td>Molded flange adapters</td>
<td>1.034 (150)</td>
<td>ASTM D2235, ASTM F2315</td>
</tr>
</tbody>
</table>

GENERAL NOTE: An appropriate derating factor shall be applied for higher-temperature applications or services.

2-3.2.5 Attachments

(a) External and internal attachments to piping shall be designed so as not to cause flattening of the pipe, excessive localized bending stresses, or harmful thermal gradients in the pipe wall.

(b) Such attachments shall be designed to minimize stress concentrations in applications where the number of stress cycles, due to either pressure or thermal effects, is relatively high for the expected life of the equipment.

2-3.2.6 Closures

(a) General. Closures shall be made by use of closure fittings, such as threaded or bonded plugs and caps, manufactured in accordance with standards listed in Table 4-2.1-1, and used within the specified pressure-temperature ratings.

(b) Openings in Closures

(1) A closure with a threaded or socketed opening shall be designed as a reducer or reducer bushing.

(2) Secondary drill and tap of a threaded or bonded plug or cap is not permitted.

2-3.2.7 Pressure Design of Flanges and Blanks

(a) Flanges — General. See Mandatory Appendix V and Nonmandatory Appendix A.

(b) Blind Flanges. Blind flanges shall be made of materials per ASME B16.5.

2-3.3 Analysis of Piping Components

(a) To validate a design under the rules in this paragraph, the complete piping system shall be evaluated between anchors for the effects of thermal expansion, weight, other sustained loads, and other occasional loads.

(b) Each component in the system shall meet the limits in this paragraph. Equations (2-3-8) and (2-3-9) may not apply for bellows and expansion joints.

(c) When evaluating piping stresses in the vicinity of expansion joints, consideration shall be given to actual cross-sectional areas that exist at the expansion joint.

2-3.3.1 Aboveground Pipe

2-3.3.1.1 Stress Due to Sustained Loads. Longitudinal stresses, $S_L$, in the pipe caused by applied pressure and bending loads in thermoplastic pipe shall satisfy eq. (2-3-8):

$$S_L = S_p + 0.75iM_A/Z \leq 1.0S$$

(2-3-8)

where

- $i$ = stress intensification factor (see Mandatory Appendix IV)
- $M_A$ = resultant bending moment due to the applicable applied sustained load
- $S$ = basic allowable stress, MPa (psi), given in ASME NM.3.3 for long-term load duration at the design temperature

17

FOR ASME COMMITTEE USE ONLY
### Table 4-2.1-1 Specifications and Standards (Cont’d)

<table>
<thead>
<tr>
<th>Designator</th>
<th>General Standards (Cont’d)</th>
<th>Title</th>
</tr>
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<tbody>
<tr>
<td>ASTM D4218</td>
<td>Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique</td>
<td></td>
</tr>
<tr>
<td>AWS B.4</td>
<td>Specification for Welding Procedure and Performance Qualification for Thermoplastics</td>
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<tr>
<td>AWS G.10</td>
<td>Guide for the Evaluation of Thermoplastic Welds</td>
<td></td>
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<tr>
<td>AWS Q.C1</td>
<td>Standard for Certification of Welding Inspectors</td>
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<tr>
<td>AWWA C207</td>
<td>Steel Pipe Flanges for Waterworks Service, Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm)</td>
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<td>CSA Z662</td>
<td>Oil and Gas Pipeline Systems</td>
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<tr>
<td>DIN 2501</td>
<td>PN16 Plate Flange</td>
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<tr>
<td>DVS 2207-1</td>
<td>Welding of thermoplastics — Heat element welding of pipes, piping parts and panels made out of polyethylene</td>
<td></td>
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<tr>
<td>DVS 2207-5</td>
<td>Welding of thermoplastic materials — Testing and assessing welded joints in PE casing pipes</td>
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<tr>
<td>DVS 2207-6</td>
<td>Welding of thermoplastics — Non-contact heated tool butt welding of pipes, pipeline components and sheets — Methods, equipment, parameters</td>
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<tr>
<td>DVS 2207-11</td>
<td>Welding of thermoplastic materials — Heat element welding of pipes, piping parts and panels made of PP</td>
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<tr>
<td>DVS 2207-15</td>
<td>Welding of thermoplastics — Heat tool welding of pipes, piping parts and panels made of PVDF</td>
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<tr>
<td>DVS 2210-1</td>
<td>Industrial piping made of thermoplastics — Design and execution — Above-ground pipe systems — Recommendations for the internal pressure and leak tests</td>
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<tr>
<td>DVS 2212-1</td>
<td>Qualification testing of plastic welders — Qualification Test Groups I and II</td>
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<tr>
<td>EN 1092-1:2002</td>
<td>Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges</td>
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</tr>
<tr>
<td>EN 12814-7:2002</td>
<td>Testing of welded joints in thermoplastics semi-finished products — Part 7: Tensile test with waist test specimens</td>
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<tr>
<td>EN 13067:2003</td>
<td>Plastics welding personnel — Qualification testing of welders — Thermoplastics welded assemblies</td>
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<tr>
<td>EN 13100-1</td>
<td>Non-destructive testing of welded joints of thermoplastics semi-finished products — Part 1: Visual examination</td>
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<tr>
<td>ISO 161/1:1978</td>
<td>Thermoplastic pipes for the transport of fluids — Nominal outside diameters and nominal pressures — Part 1: Metric series</td>
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<tr>
<td>ISO 7005-1:1992</td>
<td>Metallic flanges — Part 1: Steel flanges</td>
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<tr>
<td>PPI TR-3</td>
<td>Policies and Procedures for Developing Recommended Hydrostatic Design Basis (HDB), Hydrostatic Design Stresses (HDS), Pressure Design Basis (PDB), Strength Design Basis (SDB), and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe</td>
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<td>PPI Listing of Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength (MRS) Ratings for Thermoplastic Piping Materials or Pipe</td>
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<tr>
<td>PPI TR-45</td>
<td>Butt Fusion Joining Procedure for Field Joining of Polyamide-11 (PA-11) Pipe</td>
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#### ABS Standards

<table>
<thead>
<tr>
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<tr>
<td>ASTM D3965</td>
<td>Standard Classification System and Basis for Specifications for Rigid Acrylonitrile-Butadiene-Styrene (ABS) Materials for Pipe and Fittings</td>
</tr>
<tr>
<td>ASTM F2969</td>
<td>Standard Specification for Acrylonitrile-Butadiene-Styrene (ABS) IPS Dimensioned Pressure Pipe</td>
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#### CPVC Standards

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<tbody>
<tr>
<td>ASME SD-1784</td>
<td>Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds</td>
</tr>
<tr>
<td>ASME SD-2846/SD-2846M</td>
<td>Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Hot-and-Cold-Water Distribution Systems</td>
</tr>
</tbody>
</table>
2-3 PRESSURE DESIGN OF PIPING COMPONENTS

2-3.1 Criteria for Pressure Design of Piping Components

The design of piping components shall consider the effects of pressure and temperature, in accordance with paras. 2-3.2.1 through 2-3.2.7, including the consideration of variations and allowances permitted by paras. 2-2.2.4 and 2-2.4. In addition, the mechanical strength of the piping system shall be determined adequate in accordance with para. 2-3.3 under other applicable loadings, including, but not limited to, those loadings and conditions defined in sections 2-1 and 2-2.

2-3.2 Pressure Design of Components

2-3.2.1 Straight Pipe

2-3.2.1.1 Straight Pipe Under Internal Pressure

(a) The minimum required wall thickness, \( t_{\text{min}} \), of straight pipe sections for pressure design shall be determined by the following:

(1) For O.D.-controlled pipe

\[
 t_{\text{min}} = \frac{P_D D + A}{2S + P_D}
\]

(2) For I.D.-controlled pipe

\[
 t_{\text{min}} = \frac{P_D d + 2S A + PA}{2S - P_D}
\]

where

- \( A \) = an allowance to be determined by the designer for threading, grooving, erosion, or other wall loss mechanisms, mm (in.)
- \( D \) = specified or actual outside diameter, mm (in.)
- \( d \) = specified or actual inside diameter, mm (in.)
- \( P \) = internal pressure, MPa (psig)
- \( P_D \) = design pressure, MPa (psig)
- \( S \) = maximum allowable stress from ASME NM.3.3, Table 1-1-1, MPa (psi)

When the pipe is subjected to scratches, dents, or other damage during construction, the remaining pipe wall thickness shall be greater than or equal to \( t_{\text{min}} \) plus any erosion or other required allowance.

(b) The maximum allowable working pressure, \( P_a \), shall be determined as follows:

(1) For O.D.-controlled pipe

\[
 P_a = \frac{2S(t - A)}{D - (t - A)}
\]

(2) For I.D.-controlled pipe

\[
 P_a = \frac{2S(t - A)}{d - (t - A) + 2t} = \frac{2S(t - A)}{d + A + t}
\]

where \( t \) = minimum wall thickness from the standard to which the pipe was made, accounting for manufacturing tolerances, or the minimum measured wall thickness, mm (in.)

2-3.2.1.2 Straight Pipe Under External Pressure. See Nonmandatory Appendix B for recommended requirements for external pressure design of buried piping systems.

2-3.2.1.3 Allowable Pressure Due to Pressure Spikes. For straight pipe made of HDPE, the sum of the maximum anticipated operating pressure plus the maximum anticipated occasional pressure spikes shall be not greater than \( 1.5P_D \). The maximum permitted duration of the pressure spike is 15 min, and the total duration of the pressure spikes shall be less than 20 h/yr.

2-3.2.2 Joints or Fittings. This paragraph provides the design requirements and limitations for joints or fittings in thermoplastic piping systems.

(a) General Requirements for All Thermoplastics

(1) See Chapter 5 for allowable joining methods for each type of listed thermoplastic.

(2) The piping components permitted in section 2-3 shall be designed to withstand a pressure greater than or equal to the design pressure of the attached pipe.

(3) See Mandatory Appendix II for requirements on threaded thermoplastic connections.

(4) See Mandatory Appendix III for acceptance criteria for thermoplastic joints.

(b) Requirements Specific to HDPE. Pipe fittings, including electrofusion fittings, shall be designed to withstand a pressure greater than or equal to the design pressure, \( P_D \), of the attached HDPE pipe.

(1) The pressure rating (PR) of the fitting shall be determined by testing or by the following calculation:

\[
 PR = \text{GSR} \left( \frac{2S}{\text{DR} - 1} \right) \geq P_D
\]

where GSR is the geometric shape rating factor per Table 2-3.2.2-1 and DR is the dimensional ratio \( D/t \).

(2) For components of different DRs, the item with the smaller DR shall be counterbored and tapered to equal the wall thickness of the item with the larger DR, or its outside diameter shall be machined and tapered to equal the wall thickness of the item with the larger DR and shall comply with Figure 2-3.2.2-1, illustration (a) or illustration (b), as applicable. This requirement shall be identified on the design and fabrication drawings.

(c) Materials Other Than HDPE. Tables 2-3.2.2-2 and 2-3.2.2-3 list the design factors (DF) and pressure ratings (PR), respectively, for non-HDPE thermoplastic...
Chapter 5
Fabrication, Assembly, and Erection

5-1 GENERAL

5-1.1 SCOPE

(a) This chapter contains the requirements for the qualification of welders, fusing operators, joiners, and the material processes used during fusing and joining operations. This chapter is divided into the following parts:

(1) 5-1 contains the general requirements for all material joined processes

(2) 5-2 contains requirements for thermoplastic fusion

(3) 5-3 contains requirements for solvent-fusion

(b) Whenever the referencing Code, standard, or specification imposes qualification requirements different than those given in this chapter, the requirements of the referencing Code, standard, or specification shall take precedence over the requirements of this chapter.

(c) Throughout this chapter, references are made to various non-ASME documents. Unless a specific date is referenced, the latest edition of the reference document in effect at the time of performance or procedure qualification is to be used.

(d) Thermoplastic piping materials and components shall be prepared for assembly and erection by one or more of the fabrication processes covered in this chapter, as applicable.

(e) The requirements for the processes used for assembly and/or erection shall be the same as those used for fabrication.

(f) The joiner (also called welder or fusing operator) shall be employed by an entity that is responsible for fabrication, assembly, and/or erection.

(g) The acceptable jointing procedure qualification record (PQR) for different thermoplastics shall be as specified in this Section.

(h) The acceptable fusion procedure specification (FPS) for the different thermoplastics shall be as specified in this Chapter.

5-1.2 JOINING THERMOPLASTIC PIPING COMPONENTS

The components used in thermoplastic piping systems are composed of various polymeric compounds. Various methods may be used to join different polymeric compounds. Three common joining methods are heat fusion, solvent-cement welding, and mechanical joining.

Heat fusion and solvent-cement welding are discussed in this Chapter. Mechanical joining is discussed in the following sections:

(a) Chapter 8 discusses mechanical joining for multi-layered reinforced thermoplastic piping systems.

(b) Mandatory Appendix II discusses requirements for threaded thermoplastic connections.

(c) Mandatory Appendix V discusses requirements for one-piece thermoplastic flanges.

(d) Nonmandatory Appendix A provides guidance for mechanical joining using lap-joint thermoplastic flanges (LJTFs).

NOTES:

(1) All joining processes do not work on all thermoplastics. The selection of compounds and joining techniques is based on the selected thermoplastic and the application requirements.

(2) Mechanical joining is a joining method in which a device or fitting, rather than heat fusion or solvent-cement welding, is used to connect the thermoplastic pipe sections. The term “mechanical fittings or devices” applies only to:

(a) stab-type fittings

(b) nut-follower-type fittings

(c) bolted-type fittings

(d) other compression-type fittings

5-1.3 PROCEDURE SPECIFICATION

A procedure specification is a written document providing direction to the person applying the material joining process. Details for the preparation and qualification of procedure specifications for fusing, and bonding are given in the respective Parts addressing those processes.

Procedure specifications used by an organization having responsibility for operational control of material joining processes shall have been qualified by that organization or shall be a standard procedure specification acceptable under the rules of the applicable Part for the joining process to be used.

Procedure specifications shall be available for reference and review.

Procedure specifications address the conditions (including ranges, if any) under the material joining process must be performed. These conditions are referred to in this chapter as “variables”.

The procedure specification shall address, as a minimum, the specific essential and nonessential variables that are applicable to the material joining process to be used.

5-1.4 Standard Fusing Procedure Specification
(a) Standard Fusing Procedure Specification (SFPS)

(1) Prerequisites:

- And SFPS is a fusing procedure specification that contains acceptable fusing variables(b) based on standard industry practice and testing as defined in ASTM F2620.
- An SFPS may be used for production fusing by organizations without further qualification. (c)

(2) Contents of the SFPS:

- The SFPS shall address all of the essential and nonessential variables listed in Table 5-1A(d) through 5-1D.
- In addition, the SFPS shall include all of the conditions listed in this chapter.
- The organization may include any additional(e) information in the SFPS that may be helpful in making a fused joint.

(3) Changes:

- Changes in the essential variables or conditions of an SFPS beyond the limits specified in chapter shall require the qualification of an FPS.

(b) Manufacturer Qualified Electrofusion Procedure Specification (MEFPS)

(1) Prerequisites:

- An MEFPS is an electrofusion procedure that has been qualified by an electrofusion fitting manufacturer, based on standard industry practice in accordance with the Plastic Pipe Institute (PPI), Technical Note TN-34 and ASTM F1290, for the electrofusion fitting manufacturer's specific electrofusion joint design, and qualified by the electrofusion fitting manufacturer in accordance with ASTM F1055 to define the ranges for the essential variables identified in Table 5-1.
- An MEFPS may be used for production by organizations fusing the same electrofusion fitting manufacturer's qualified fittings without further qualification.

(2) Contents of the MEFPS:

- The MEFPS shall address all essential and nonessential variables listed in Table 5-1A thru D.
- In addition, the MEFPS shall include all of the conditions listed in this Chapter.
- The manufacturer or employer may include any additional information in the MEFPS that may be helpful in making a fused joint.

(3) Changes:

- Changes in the essential variables or conditions of an MEFPS beyond the limits specified in this Chapter or Table 5-1A thru D shall require the qualification of an FPS.

5-1.5 Procedure Qualification Record

(a) The purpose of qualifying the procedure specification is to demonstrate the joining process proposed for fabrication, assembly, and/or erection is capable of producing joints having the required mechanical properties for the intended application.

Qualification of the procedure specification demonstrates the mechanical properties of the joint made using a joining process, and not the skill of the person using the joining process.

The procedure qualification record (PQR) documents what occurred during the production of a procedure qualification test coupon and the results of testing that coupon.

As a minimum, the PQR shall document the essential procedure qualification test variables applied during production of the test joint, and the results of the required tests.

The organization shall certify the PQR by a signature or other means as described in the organization's Quality Control Systems.

The PQR shall be available for review.

A procedure specification may be supported by one or more PQR(s), and one PQR may be used to support one or more specification(s).

5-1.6 Performance Qualification

The purpose of qualifying the person who will use a joining process is to demonstrate that person's ability to produce a sound joint when using a procedure specification.

5-1.7 Performance Qualification Test Record

The performance qualification test record documents what occurred during the production of a test coupon by a person using one or more joining processes following an organization's procedure specification. As a minimum, the record shall document the following:

(1) The essential variables for each process used to produce the test coupon
(2) The ranges of variables qualified as required by the applicable Part
(3) The results of the required testing and nondestructive examinations
(4) The identification of the procedure specification(s) followed during the test

The organization shall state on the record that the performance qualification test was conducted in accordance with the requirements of this chapter and certify the record by signature or other means as described in the organization's Quality Control System.

Performance qualification shall be available for review.

5-1.8 Variables

5-1.7.1 Essential Variables (Procedure)

Essential procedure variables are conditions in which a change, as described in the specific variables, is considered to affect the mechanical properties of the joining.

Before using a procedure specification whose essential variables have been revised and fall outside their qualified range, the procedure specification must be requalified.
(c) Procedure qualification records may be changed when a procedure qualification test supporting the change has been completed, or when an editorial revision is necessary to correct an error, as permitted by the rules of the Part applicable to the material-joining process.

5-1.7.2 Essential Variables (Performance)
Essential performance variables are conditions in which a change, as described in the specific variable list, will affect the ability of the person to produce a sound joint.

5-1.7.3 Supplementary Essential Variables
(a) Supplementary essential variables are conditions in which a change will affect the properties of the joint, heat-affected zone, or base material.
(b) Supplementary essential variables become additional essential variables in situations where procedure qualifications require testing.
(c) When procedure qualification does not require additional testing, supplementary essential variables are not applicable.

5-1.7.4 Nonessential Variables
Nonessential variables are conditions in which a change, as described in the specific variables, is not considered to affect the mechanical properties of the joint. These variables shall be identified in the procedure specification.
(a) A procedure specification may be editorially revised to change a nonessential variable to fall outside of its previously listed range but does not require requalification of the procedure specification.

5-1.7.5 Special Process Variables
(a) Special process variables are conditions that apply only to special fusing or joining processes that are described in the Part that addresses those processes.
(b) When these special processes are used, only the applicable special process variables shall apply.

5-1.7.6 Applicability
(a) The applicable essential, supplementary essential, nonessential, and special process variables for a specific joining process are given in the Part addressing that joining process.

5-1.9 ORGANIZATIONAL RESPONSIBILITY
(a) Employers are responsible for all joining of thermoplastic components and subassemblies by their personnel. In addition, employers shall:
(1) Conduct the qualification tests required to qualify a Procedure Specification used by their personnel.
(2) Conduct the qualification tests required to certify the operators, welder or joiners.
(3) Train and qualify Inspectors and Examiners in accordance to the requirements in Chapter 6.
(4) Conduct the requalification test required to maintain qualifications for operators, welders or joiners.
(b) Personnel performing supervisory activities specified in this chapter shall:
(1) Be designated by the organization with responsibility for certifying qualification documents.
(2) Have a satisfactory level of competence in accordance with the organization’s quality program. As a minimum, they shall be qualified by education, experience, or training in the following areas:
- Knowledge of the requirements of this chapter for the qualification of procedures and/or joining personnel
- Knowledge of the organization’s quality program
- The scope, complexity, or special nature of the activities to which oversight is to be provided
(3) Have a record, maintained by the organization, containing objective evidence of the qualifications, training or experience.

5-1.8.1 Procedure Qualification
Each employer is responsible for conducting the tests required by this chapter to qualify the procedures that are used in the fabrication, erection, and assembly of components under the rules of the Codes, standards, and specifications that reference this chapter.

(a) Each employer shall:
(1) Have a record, maintained by the organization, containing objective evidence of the qualifications, training or experience.
(2) Conduct requalification tests under the supervision and control of another organization is not permitted.

(b) The subsequent work for preparing test specimens from the completed test joint, and the performance of nondestructive examination and mechanical tests, provided the organization accepts full responsibility for any such work.

If the effective operational control of procedure qualifications of two or more companies of different names exists under the same corporate ownership, the companies involved shall describe their Quality Control System or Quality Assurance Program the operational control of procedure qualifications.

(1) In this case, separate procedure qualifications are not required, provided all other requirements of this chapter are met.

Changes to the PQR are not permitted except for documented editorial corrections or those utilizing addenda.

(a) Additional information may be incorporated into a PQR at a later date, provided the information is substantiated as having been associated with the original qualification conditions by use of lab records or similar documented evidence.
(b) All changes to a PQR require recertifications (including date) by the organization.

The information required to be in the PQR may be in any format, written or tabular, to fit the needs of each organization, provided all essential variables are included.
(1) The types and number of tests, and their results shall be reported on the PQR.

(2) When required, additional sketches or information may be attached or referenced to record the required variables.

5-1.8.2 Performance Qualifications

(a) Each organization is responsible for the supervision and control of material joining performed by persons for whom they have organizational control.

(b) The organization shall conduct the tests required by this chapter to qualify the performance of those persons with each joining process they will be using for fabrication, assembly, and/or erection of components under the rules of this chapter.

(c) This requirement ensures that the qualifying organization has determined that the personnel using its procedures are capable of achieving the minimum requirements for an acceptable joint. This responsibility cannot be delegated to another organization.

(d) The personnel who produce test joints for performance qualification shall be tested under the full supervision and control of the qualifying organization.

(e) The performance qualification test shall be performed following either a qualified procedure specification or a standard procedure specification acceptable under the rules of the applicable Part for the joining process.

(1) The Part addressing any specific joining process may exempt a portion of the procedure specification from being followed during production of the performance qualification test coupons.

(f) The performance qualification test may be terminated at any stage, whenever it becomes apparent to the supervisor conducting the tests that the person being tested does not have the required skill to produce satisfactory results.

(g) When a procedure qualification test coupon has been tested and found acceptable, the person who prepared the test coupon is also qualified for the joining procedure used, within the ranges specified for performance qualification for the applicable process(es).

(h) Persons who are successfully qualified shall be assigned an identification number, letter, or symbol by the organization, which shall be used to identify their work.

(i) If effective operational control of performance qualifications for two or more companies of different names exists under the same corporate ownership, the companies involved shall describe in their Quality Control System or Quality Assurance Program, the operational control of performance qualifications.

(1) In this case, requalification of persons working within the companies of such an organization are not required, provided all other requirements of this chapter are met.

(j) The record of operator performance qualification tests shall include the qualified ranges of essential performance variables, the type of tests performed, and test results for each operator.

5-1.8.3 Simultaneous Performance Qualifications

Organizations may participate in an association to collectively qualify the performance of one or more persons for material-joining processes simultaneously and may share performance qualification information with other participating organizations within the association.

(b) When simultaneous performance qualifications are conducted, each participating organization shall be represented by an employee with designated responsibility for performance qualifications.

(c) The essential variables of the procedure specifications to be followed during simultaneous performance qualifications shall be compared by the participating organizations, and shall be identical, except as otherwise proved in the Part addressing the specific joining method. The qualified thickness ranges do not need to be identical but shall include the test coupon thickness.

Alternatively, the participating organizations shall agree to follow a single procedure specification that has been reviewed and accepted by each participating organization.

(1) Each participating organization shall have a supporting PQR or shall have accepted responsibility for using a standard procedure specification having a range of variables consistent with those to be followed during the performance, qualification test, in accordance with the applicable Part for the joining method.

Each participating organization’s representative shall:

(1) Positively identify the person whose performance is to be tested

(2) Verify the markings on the test coupon correspond to the person’s identification

(3) Verify that the positional orientation markings on the test coupon reflect the test position of the coupon as required to identify the location of test specimen removal

(4) Perform a visual examination of each completed test coupon and each test specimen to determine its acceptability

- When the test coupon(s) is prepared and the test specimens are mechanically tested by an independent laboratory, the laboratory’s report may be used as the basis for accepting the test methods and their results.
- When the test coupons(s) is examined by volumetric examination, the examining organization’s report may be used as the basis for acceptance of the test methods, qualification and certification of the examiner, and the results of the examination.

(5) Prepare and certify a performance qualification record for each person qualified

When the qualified person changes employers between participating organizations, the employing organization shall verify the continuity of the person’s qualifications has been maintained by previous employers since his qualification date, as required by the applicable Part for the joining method.

(1) Evidence of activities supporting performance qualification continuity may be obtained from any member of the association, even is the member was not a participant in the simultaneous welder qualifications.
(g) If a person has had their performance qualification revoked for specific reasons, the employing organization shall notify all other participating organizations that the person’s qualification(s) has been revoked. The remaining participating organizations shall determine whether they will uphold or revoke the performance qualifications for that person in accordance with this chapter.

(h) When a person’s performance qualifications are collectively renewed in accordance with the applicable Part for the joining method, the testing procedures shall follow the rules of this paragraph.

5-1.9 OWNERSHIP TRANSFERS

(a) Organizations may maintain effective operational control of PQRs, procedure specifications, and performance qualification records under different ownership than existed during the original procedure qualification.

(b) Multiple organizations under a common ownership may use PQRs, procedure specifications, and performance qualification records under that Owner’s name.

(1) The Quality Control System or Quality Assurance Program of each organization shall describe the effective operational control and authority for technical direction of welding.

(c) When an organization or some part thereof is acquired by a new Owner(s), the PQRs, procedure specifications, and performance qualification records may remain valid for use by the new Owner(s) without qualification. The new Owner(s) PQRs, procedure specification, and performance qualification records become valid for use by the acquired organization, provided all of the following requirements have been met:

(1) The new Owner(s) take responsibility for the procedure specification records.

(2) The procedure specification(s) identify the name of the new Owner(s) prior to use.

(3) The Quality Control System or Quality Assurance Program documents the original source of the PQRs, procedure specifications, and performance qualification records as being from the original qualifying organization.

5-1.10 QUALIFICATION TESTS

(a) Orientation categories for fused joints are illustrated in Figure 5-1.

(b) Fused joints may be made in test coupons oriented in any of the positions shown in Figure 5-2.

5-1.10.1 Test Records Requirements

The following variables shall be recorded for each fused joint, as applicable.

5-1.10.1.1 Butt and Side Wall Fusing Procedures

(a) Gauge pressure and elapsed time during the fusing and cool cycle

(b) Drag pressure when applicable

(c) Joint configuration

(d) Pipe diameter and wall thickness

(e) Type of material (specification and classification)

(f) FPS used, operator identification, time, date, and fusing machine identification

5-1.10.1.2 Electrofusion Procedures

(a) Date

(b) Ambient Temperature

(c) Material Temperature

(d) Pipe and diameter and wall thickness

(e) The FPS used

(f) Nominal fusion time

(g) Adjusted fusion time

(h) Termination code

(i) Fitting description

(j) Elapsed time for fusion and cooling

(k) Operator identification

(l) Operator verification of scraping and cleaning

(m) Fit-up gap

(n) Fusion number

(o) Fusion machine identifier

(p) Voltage

(q) Preheat voltage and time, if applicable

5-1.10.1.3 Manual Butt Fusing Procedure

(a) Heater surface temperature immediately before inserting the heater plate

(b) Verification that heating pressure was reduced to zero after initial indication of melt

(c) Elapsed time during the heat soak cycle

(d) Heater removal (dwell) time

(e) Elapsed time during the fusing and cooling time

(f) Joint configuration

(g) Pipe diameter and wall thickness

(h) Type of material (specification and classification)

(i) FPS used, operator identification, time, date, and fusing machine identification

5-1.10.2 Tests Records Review

(a) The tests record for each fused test joint shall be compared to the FPS after completion.

(b) The reviewer shall verify that the conditions meet the requirements in this chapter.

(c) If the recorded data is found to be outside the limits specified in the FPS, the joint will be deemed unacceptable

5-1.10.2.1 Butt and Sidewall Fusing Qualification

(a) Interfacial fusing pressure was within the FPS range.

(b) Heater surface temperature recorded was within the FPS range.

(c) Fusing pressure applied during the fusing and cool
5-1.10.2.2 Electrofusion Qualification
(a) 
(b) Voltage was within the FPS range
(c) Nominal fusion time was within the FPS range.
(d) Absence of any electrical fault during fusion operation.
(e) Cooling time at fusing pressure met the minimum time specified in the FPS.

5-1.10.2.3 Manual Butt Fusion Qualification
(a) All data required in this chapter were recorded
(b) Heater surface temperature recorded was within the FPS range.
(c) Fusing machine was opened at the end of the heat soak cycle, the heater was removed, and the joint pipe ends were brought together at the fusing pressure within the time frame specified by the FPS.
(d) Cooling time at butt fusing pressure met the minimum time specified by the FPS.

5-2 THERMOPLASTIC FUSING REQUIREMENTS

5-2.1 Scope
(a) The rules in this Part apply to the preparation and the qualification of the fusing procedure specification (FPS), and the performance qualification of fusing operators.
(b) The procedure shall be prepared and as required in Chapter 8; Mandatory Appendix I; ASME BPVC, Section IX, Article XXII; CSA Z662; ASME BPE, Part M; or DVS 2212-1, or this Standard.
(c) Performance qualifications shall be qualified in accordance with Chapter 8; Mandatory Appendix I; ASME BPVC, Section IX; or this Standard.

5-2.2 Procedure Qualifications
5-2.2.1 Procedure Qualification Specifications.
(a) The FPS to be used for joining thermoplastic pipe, fittings, and components in production shall be prepared and qualified by the employer.
(b) Several FPSs may be prepared from the qualification test data recorded on a single PQR. A single FPS may encompass the range of qualified essential variables represented by multiple PQRs supporting the qualified combination and range of essential variables.
(c) To avoid duplication of effort, an employer may accept an FPS qualified by a technically competent group or agency provided it complies with the following:
(1) The procedure specification meets the requirements of this chapter.
(2) The employer shall have qualified at least one fusing operator using the qualified FPS
(3) The employer's trade name or mark shall be shown on the qualified FPS to be used and on each procedure qualification record (PQR). In addition, the PQRs shall be signed and dated by the employer, who thereby accepts responsibility for the qualification performed by others.
(4) Owner's approval for using the procedure specification qualified by others shall be documented prior to its use.
(d) The completed FPS shall address all of the essential and nonessential variables for each fusion process used in the FPS. The employer may include any other information in the FPS that may be helpful in making a fused joint.
(e) Changes in the documented essential variables require requalification of the FPS.

5.2.2.2 FPS Format
(a) The information required to be included in the FPS may be in any format, written, or tabular to fit the needs of the employer, provided all the essential and nonessential variables are addressed.

5-2.3 FUSION Performance Qualifications
(a) Thermoplastic fusing operators, welders, and joiners shall be qualified in accordance with Chapter 8; Mandatory Appendix I; ASME BPVC, Section IX; or this chapter.
(b) Every fusing operator shall be trained to the appropriate FPS, by qualified personnel who have been trained and tested as required in this Standard or as required for fusing in CSA Z662 or DVS 2207.
(c) To avoid duplication of effort, an organization may accept the performance qualification of a fusing operator, welder, or joiner granted by a previous employer.
(1) The previous employer's performance qualifications and procedure specifications essential variables shall be within the limits established in ASME BPVC Section IX or this Standard.
(2) The new employer shall have a copy of the previous employer's PQR and procedure specification that was followed during qualification. The PQR and procedures specification shall show the name of the employer by whom the fusing operator, welder, or joiner was qualified and the date of that qualification.
(3) Evidence shall also be provided that the fusing operator, welder, or joiner has maintained qualification in accordance with Chapter 8; Mandatory Appendix I; ASME BPVC, Section IX; CSA Z662; or DVS 2212-1, except that this evidence may be provided by an employer responsible for the individual's fusing or welding or joining performance even if not the original qualifying employer.
(4) The current employer's business name shall be shown on the qualification record, and it shall be
signed and dated by the employer, who thereby accepts responsibility for the qualifications performed by others. 
(5) Employer's approval for performance qualification of fusing operator, welder, or joiner by others shall be documented prior to being used.
(6) If the previous employer's documentation is not available then the fusing operator, welder, or joiner shall be requalified.

(3) **Qualification Records**

(a) The employer shall maintain copies of the procedure and performance qualification records specified in Chapter 8; Mandatory Appendix I; ASME BPVC, Section IX, Article XXII; or this Standard. CSA Z662; and DVS 2212-1. These copies shall be available to the owner at the location where fabrication, assembly, and erection are being done.
(b) The employer shall be responsible for maintaining records.
(c) The retention period for qualification records shall be 5 yr after qualification.

5.2.4 **VARIABLES**

5.2.4.1 **General**
(a) For each specific fusing process, the fusing variables described in this Chapter are applicable for the procedure qualification or requalification.
(b) For each specific fusing process, the fusing variables described in this Chapter are applicable for the performance qualification or requalification.
(c) A change from one fusing process to another fusing process requires requalification (i.e. a change from butt fusing to electrofusion).
(d) The fusing data includes the fusing variables groups such as pipe material, position, thermal conditions, and technique.
(e) Table 5-1 thru 1D list the essential and nonessential variables.

5.2.4.2 **Joins**
(a) A change in the pipe O.D. surface misalignment
(b) Any change in the design of an electrofusion joint that causes a change in any other essential variables of Table 5-1A thru 1D. The configuration of a fitting may change without impacting those variables. For example:
(1) From a 90-degree elbow to a 45-degree elbow
(2) From an NPS 2 x NPS 8 (DN 50x DN 200) saddle connection to an NPS 3 x NPS 8 (DN 80 x DN 200) saddle connection.
(c) An increase in the maximum radial fit-up gap qualified. This variable may be expressed in terms of maximum alignment and out-of-roundness.
(d) A change from socket-type (full wrap) joint to saddle type (partial wrap) joint, and vice versa.

5.2.4.3 **Material**
(a) A change in the pipe diameter beyond the range qualified in Table 5-2.
(b) A change in the pipe wall thickness beyond the range qualified in the FPS.
(c) A change in the thickness or cross-sectional area to be fused beyond the range specified.
(d) An increase in heater plate removal time from that qualified.
(e) A decrease in the cool time are pressure from that qualified.
(f) A change in fusion voltage.
(g) A change in the nominal fusion time.
(h) A change in material fusing temperature beyond the range qualified.
(i) A change in initial heating pressure beyond the range qualified.

5.2.5 **Thermoplastic Fusion Equipment Qualifications**

5.2.5.1 **Fusion Equipment Operators**

(1) Thermoplastic fusing operators shall be trained and qualified to operate the fusing equipment to be used.
(2) The employer shall be responsible for ensuring that each fusion equipment operator has been trained and qualified for equipment to be used.
(3) The qualification shall be performed per the equipment manufacturer’s guidelines.
(4) Evidence shall also be provided that the fusion equipment has been qualified to operate the fusion equipment.
(5) The employer's business name shall be shown on the qualified record and it shall be signed and dated by the employer, who thereby accepts responsibility.
(6) A change in the fusion equipment type (i.e. manual to hydraulic) or manufacturer shall require new qualification.

5.2.5.2 **Fusion Equipment Maintenance Operators**

(1) Set-up and maintenance on fusion equipment machines shall be performed by qualified personnel.
(a) Qualification shall include initial set-up, routine maintenance, and clamp size changing.
(2) The qualification shall be performed per the equipment manufacturer's guidelines.
(3) The employer shall be responsible for ensuring that the fusion equipment maintenance
operators have been trained and qualified for the equipment to be used.

(4) Evidence shall be provided that the fusing maintenance operator have been qualified to perform work on the fusing equipment.

5-2.6 Thermoplastic Joining Using Heat-Fusion Methods

(a) In pressure piping systems, heat-fusion joining methods shall be used only to join like piping compounds.

(1) Many thermoplastic polymeric compounds cannot be joined to other, different thermoplastic compounds using standard heat fusion. There are exceptions to this general statement related to thermoplastic pipe liners.

(2) Heat Fusion requirements for PA-11 are included in Mandatory Appendix I

(3) Heat Fusion requirements for PP, PVDF, and PTFE liners are included in Mandatory Appendix I.

(b) Pipes or components made of thermoplastic compounds with the same physical properties, as shown by ASTM cell classification or by comparison of physical properties, shall be joined using a FPS, that has been qualified as specified in the Standard.

(c) Pipes or components made of thermoplastic compounds of the same or similar (copolymer and homopolymer) polymeric compounds with different ASTM cell classifications or slightly different physical properties shall be joined using a FPS, that has been qualified as specified in this Standard and approved by the owner or the owner’s representative or both.

(1) PA-11 shall not be joined to PA-12 using heat fusion.

(2) PP shall not be fused to PE using heat fusion.

(3) Medium voltage PE may be fused to high-density PE using heat fusion, as indicated in ASME BPVC, Section IX, Articles XXI through XXIV.

b. Procedure

(1) Joints shall be made in accordance with a qualified FPS that meets the applicable requirements of this Standard.

(2) For socket fusion and saddle fusion joints not addressed in this Standard, ASTM D2657 provides a basis for FPS development.

(3) Both surfaces to be joined shall be uniformly heated to produce a continuous homogenous bond between them. This will produce a small continuous fillet of fused material at the outer limits of the joint. See Figure 5-3.

(4) For piping to be used in Fuel Gas applications, the FPS shall be qualified in accordance with the requirements in the Code of Federal Regulations (49 CFR Part 192).

c. Preparation

(1) Joining surfaces shall be prepared by cutting, facing, scraping, or machining to provide a clean, smooth end or external pipe surface.

(2) Surfaces to be heat fused together shall be cleaned of any foreign material.

(3) Cuts shall be free of burrs and circumferential cuts shall be as square as those obtained by the use of a saw with a miter box or square-end sawing vise.

d. Joining Area

(1) The joining area shall be protected against adverse environmental conditions such as dirt, moisture, material shavings, oil, and other contaminants.

(2) Environmental conditions shall addressed in the FPS, for the thermoplastic.

e. Limitations

(1) Imperfections exceeding the following limitations are considered defects and shall be repaired and reexamined.

i. Unfilled or unbonded areas shall be as square as those obtained by the use of a saw with a miter box or square-end sawing vise.

f. Butt Fusion

NOTE: The terms “hot plate” and “heated tool butt welding” are used to describe butt-fusion joining. Butt fusion is also called heat fusion.

(a) The axis of the pipe is limited to the horizontal position ± 45 Degrees.

(b) The pipe ends shall be faced to establish clean, parallel mating surfaces that are perpendicular to the pipe centerline on each pipe end, except for mitered joints.

(c) For mitered butt fusion joints, the pipe faces shall be at the specific angle to produce the mitered joint.

(d) When the ends are brought together at the drag pressure, there shall be no visible gap.

(e) The external surfaces of the pipe are aligned to within 10% of the pipe wall thickness.

(f) Applied pressure during fusing shall meet the requirement of the FPS.

(g) The heater surface temperature shall meet the requirements of the FPS.

(h) The initial heating shall begin by inserting the heater into the gap between the pipe ends and applying the fusing pressure until an indication of melt is observed around the circumference of the pipe. When observed, the pressure shall be reduced to drag pressure and the fixture shall be locked in position so that no outside force is applied to the joint during the heat soak cycle.

(i) The ends shall be held in place until the minimum bead size is formed between the heater faces and the pipe ends. (See Figure 5-4)

(j) After the proper bead size is formed, the machine shall be opened, and the heater removed. The pipe...
end surfaces shall be smooth, flat, and free of contamination. The pipe ends shall be brought together, and the fusing pressure reapplied.

(k) The maximum time from separating the pipe ends from the heater until the pipe ends are pushed together shall not exceed the time given in Table 5-3.

The fusing pressure shall be maintained until the joint has cooled, after which the pipe may be removed from the fusing machine.

5-2.6.2 Sidewall Fusion

(a) The sidewall fusing tool shall be centered in a secured to the header, and adequately supported.

(b) The mating surfaces of the header and saddle fitting shall be abraded or scraped to remove oxidation and contamination.

(1) After abrading or scraping, the surfaces shall be cleaned of all dust and residue with a dry, lint-free, non-synthetic cloth.

(c) The heater shall be brought to the required temperature per the FPS and centered on the header beneath the saddle fitting.

(1) Once heater has reached temperature, the saddle fitting shall be immediately pressed against the heater with a heat-fusing force equal to the interfacial pressure, unless otherwise specified by the manufacturer of the fitting.

(2) When an indication of melt appears on the header at the apex of the saddle, the pressure shall be reduced to a heat soak pressure equal to drag pressure, unless otherwise specified by the manufacturer of the saddle fitting.

(d) The heat soak pressure shall be maintained until the appropriate melt bead is visible around the circumference of the fitting, unless a heating time is specified by the saddle fitting manufacturer.

(e) After the proper bead size is formed (or heating time is achieved), the heater shall be removed.

(1) The fusion surfaces of the header and saddle fitting shall be uniform and free of contamination.

(2) The fitting shall be pressed against the header with the heater plate removal time specified in Table 5-3, and a fusing force equal to the interfacial pressure.

(f) Maintain the fusing force until cooled.

(g) The assembly should cool a minimum of 30 additional minutes before the plug is cut out of the header or external forces are applied near the joint.

5-2.6.3 Electrofusion

(a) The pipe ends shall be cleaned with water to remove dirt, mud, and other debris.

(b) For socket-type connections, the pipe ends shall be cut perpendicular ± 5 degrees to the pipe centerline on each pipe end and fully inserted into the center of the fitting.

(c) When applicable to the material, immediately before electrofuson, the external surfaces of the pipe shall be scraped with a non-smearing scraping device to cleanly remove approximately 0.01 inches (0.25 mm) of material from the outer surfaces of the pipe, such that a complete layer of material is removed from the surfaces to be fused.

(d) In the event of touching or recontamination of the pipe after scraping, isopropyl alcohol shall be used with a clean lint-free cloth for cleaning.

(e) For socket-type connections, the pipe shall be marked with a non-petroleum-based marker for the proper insertion depth before installing the electrofusing fitting.

(1) The fitting shall be installed on the pipe end to the marked depth taking care to avoid recontamination of the clean fusion surfaces.

(f) The fitting shall be connected to the electrofusion control box with the prescribed leads.

(g) The values for fusing energy voltage, nominal fusing time, and cooling period qualified by the electrofusion fitting manufacturer based on permitted material temperature range, shall be entered into processor before energizing the coils.

(h) The power supply/generator and any extension cords shall meet the electrofusion fitting manufacturer’s specified requirements.

(i) Upon completion of energizing the coils, the leads may be disconnected. No movement of the fused assembly shall be permitted until the end of the fitting manufacturer’s prescribed cooling period.
5-2.8 Application-Specific Joint Requirements for Heat Fusion

5-2.8.1 Bead or Crevice. Some applications do not permit the presence of an inside bead or indentation (sometimes called a crevice) on the inside surface of the pipe. Depending on these limitations, various methods shall be used to prevent or eliminate beads or indentations, including fusing with the aid of a bladder or using heated or nonheated inside bead removers. The user or the designer shall be consulted for bead-size allowance.

5-2.8.2 Other Joining Processes

(a) Other joining processes that create a bead, indentation, or other changes in the inside or outside surface of the thermoplastic pipe or fitting that do not affect the joint strength may be used as long as the difference in alignment is less than 10% of the wall thickness.

NOTE: Infrared heat is used as a noncontact method of joining a limited number of thermoplastics. These requirements apply to noncontact methods of butt-fusion joining.

(b) An indentation below the nominal I.D. of the pipe may be acceptable provided the indentation or misalignment does not infringe on the minimum wall thickness required for hoop or axial strength.

5-2.8.3 Removal of I.D. Bead. For butt-fusion joints, removal of the I.D. beads shall be at the option of the user, purchaser, or designer.

5-2.8.4 Size of Bead

(a) Removal or reduction in size of the O.D. bead created during heat fusion may be performed as long as the minimum wall thickness required for hoop or axial strength or tensile load is not reduced.

(b) When O.D. bead removal is planned, inspection or examination of the bead shall be done during or after the heat-fusion process and before bead removal.

(c) No more than a 10% misalignment shall be allowed on outside beads even if minimum wall thickness requirements are met.

5-2.9 EXAMINATION AND TESTS

5-2.9.1 General Requirements

Results of required examinations and tests shall be recorded on the procedure qualification record or the performance qualification record.

5-2.9.1.1 Visual Examination

(a) Butt Fusion and Sidewall Fusion

(1) There shall be no evidence of cracks or incomplete fusing. See Figure 5-13A and 13B.

(2) Joints shall exhibit proper fused bead configuration.

(3) Variations in upset bead heights on opposite sides of the cleavage and around the circumference of fused pipe joints are acceptable.

(4) The apex of the cleavage between the upset beads of butt-fused joints shall remain above the base material surface.

(5) For sidewall-fused joints, there shall be three beads: a melt (header) bead around the saddle base, a main pipe melt bead, and a bead on the main (header) from the edge of the heating tool.

- The saddle and main (header) melt beads should be rounded and of a size recommended by the fitting manufacturer.
- The heater bead should be visible all around the fitting base but may be separate from the main (header) pipe melt bead, depending on the shape of the header.

(6) Fused joints shall not display visible angular misalignment.

- For butt-fused joints, the outside diameter mismatch shall be less than 10% of the nominal wall thickness.

(7) The data record for the FPS or performance qualification tests shall be reviewed and compared to the FPS to verify observance of the specified variables applied when completing the fused test joint.

(b) Electrofusion Assemblies

(1) There shall be no visible evidence on external and accessible internal surfaces of cracks, excess internal (I.D.) melt caused by overheating, fitting malfunction, or in complete fusion.

- Maximum fit-up gap, or maximum misalignment and out-of-roundness, shall be within the FPS limits.

(2) The data record for the FPS or performance qualification test shall be reviewed and compared to the FPS to verify observance of the specified variables applied when completing the fused test joint.

(c) Sectioned Electrofusion Joints

(1) Voids due to trapped air or shrinkage during the cooling process are acceptable only if round or elliptical in shape with no sharp corners, and provided they meet the following requirements:

- The individual voids shall not exceed 10% of the fusion zone length.
- Multiple voids shall not exceed a combined total of 20% of the fusion zone length.
- When voids are detected, additional sections or examinations shall be made to verify that the void does not follow a diametric path connecting with the pressure-containing area of the joint.

5-2.9.1.2 Pressure Tests

(a) Elevated Temperature Sustained Pressure Tests for Butt or Sidewall Fusing - These tests assess the resistance to slow crack growth of the fused joint.

(1) Test Coupons

- Fusion joint test coupons shall be made with minimum of NPS 8 (DN 200) DR 11 pipe or the maximum size to be fused, whichever is less.
- The completed test coupons shall contain pipe on either side of the butt or sidewall joint with a minimum length of 1.5 times the joint...
(header) outside diameter or 12 inches (300 mm), whichever is greater, from the fused joint to free-end closures on the ends of the assembly.

- The testing shall be performed in accordance with ASTM D3035 or F714 for pipe, or ASTM F905 for saddle fittings.
- Manual butt fusion joint test coupons shall be made with a maximum of NPS 6 (DN 150) DR 11 pipe or the maximum size to be fused, whichever is less.

(2) Test Conditions
- Test Temperature – all tests shall be conducted at 176°F ± 4°F (80°C ± 2°C).
- Test Pressure – the assemblies are to be subjected to pipe fiber stresses as shown in Table 5-4.

(3) Test Procedures
- Elevated temperature sustained pressure tests shall be performed in accordance with ASTM D3035 or F714 for pipe, or ASTM F905 for saddle fittings.

(4) Acceptance Criteria
- Any failures within the specified time periods shall be of the pipe, independent of the joint.
- With one ductile pipe failure, the average time before failure for all three specimens shall not be less than the specified time.
- If more than one ductile pipe failure occurs at the higher pressure, the pressure of the test may be reduced and repeated until 1000-hour results are obtained.
- Any brittle failures shall necessitate new tests using different pipe.

(b) Elevated Temperature Sustained Pressure for Electrofusion – These tests assess the resistance to slow crack growth at points of stress concentration due to electrofusion fitting design.

(1) Test Coupons
- Four test coupons shall be prepared and conditioned in accordance to ASTM F1055. Pipe material PE designation shall not be less than the electrofusion fitting.

(2) Test Conditions
- Test Temperature – all tests shall be conducted at 176°F ± 4°F (80°C ± 2°C).
- Test Pressure – the assemblies are to be subjected to pipe fiber stresses as shown in Table 5-4.

(3) Test Procedures
- Elevated temperature sustained pressure testing shall be performed in accordance with ASTM F1055.

(4) Acceptance Criteria
- Any failures within the specified time periods shall be of the pipe, independent of the joint.
- If more than one ductile pipe failure occurs at the higher pressure, the pressure of the test may be reduced and repeated until 1000-hour results are obtained.
- Any brittle failures shall necessitate new tests using different pipe.

5-2.9.1.3 Bend Tests
(a) Reverse Bend Test (RBT) – this test is for butt or sidewall fusion joints of pipe with a wall thickness approximately 1 inch (25 mm) or less but may be used for thicker pipe.

(1) Test Specimens – reverse bend test specimens shall be cut to a minimum width of 1.5 times the test coupons thickness for testing and removed as shown in Figure 5-5A and 5-5B.

(2) Test Conditions
- Test Temperature – The reverse bend test shall be conducted at temperature between 60°F to 80°F (16°C to 27°C).

(3) Test Procedures
- One test specimen shall be bent to place the outside surface of the joint in tension. For butt fusion, an additional test specimen shall be bent to place the inside surface of the joint in tension.
- The bending process shall ensure the ends of the specimens are brought into contact with one another.
- Testing shall be performed in accordance with ASTM F2620, Appendix X4.
(b) Guided Butt Fusion Side-Bend Test (GSBT) – this test is limited to butt fusion joints of pipe with a wall thickness greater than 1 inch (25mm).

(2) Test Specimens
- Test specimens shall be removed from the fused test coupon with the upset bead remaining on the outside and inside surfaces.
- A strip having the full thickness of the test coupon and measuring approximately 1 inch (25 mm) wide and 18 inches (450 mm) long shall be removed along the longitudinal axis of the test coupon, with the joint located in the approximate center of the strip. See Figure 5-5.
- Plane or machine the width to 0.25 inches ± 0.02 inches (6.4 mm ± 0.5mm) with a smooth finish on both sides. See Figure 5-5.

(3) Test Conditions
- Test Temperature – Conduct the GSBT at 60°F to 80°F (16°C to 27°C).
- Test Speed – the elapsed time of the test shall be between 30 seconds to 60 seconds.

(c) Guided Side Bend Test Procedure
(1) Jigs
- The test specimens shall be bent in a test jig consisting of a fixed member with two support mandrels to support the specimen while force is applied.
- The hydraulic ram, used to supply the bending force, is also attached to the jig and has a ram attached to the end of the cylinder. See Figure 5-5.

(2) Bend Procedure
- Position the side bend test specimen with the butt fusion joint in the center of the jig between the support mandrels.
- Position the ram in the center of the fusion bead on the test specimen.
- Move the ram slowly until it makes contact with the test specimen and is positioned in line with the fusion bead.
- Begin to apply the bending force and deflect the side bend test specimen.
- The test is complete when the test specimen is bent to a maximum included angle of 90 degrees as shown in Figure 5-5A and 5-5B or until failure occurs.
- The convex surface of the specimen shall be visually examined after testing, with the specimen either in or removed from the test fixture.
- Due to specimen spring back, examination immediately after removal from the fixture is recommended.

(3) Acceptance Criteria
- The test specimen shall not break or exhibit cracking or fractures on the convex (outer) surface at the fusion interface during the test.

(d) Electrofusion Bend Test – this test is used to access the integrity of electrofusion couplings and fittings. It is used for couplings and fittings NPS 12 (DN 300) and greater.

(1) Test Specimens
- Socket Fittings (Full Wrap) - test coupons shall be prepared and conditioned, with four specimens cut from each half of the fitting and machined to 1/16-inch (1.5 mm) width in accordance with ASTM F1055. See Figure 5-6.
- Saddles (Not full wrap) –
  - The stack and bottom half of the pipe should be removed.
  - The saddle shall be cut in half in the transverse direction and then each half cut again in the longitudinal directions. See Figure 5-6.
  - Two diagonal quarters shall be used for the transverse specimens, and the two remaining diagonal quarters shall be used for the longitudinal specimens. See Figure 5-6.

(2) Test Conditions
- Test Temperature – The test shall be performed at 73°F ± 4°F (23°C ± 2°C), unless otherwise specified.

(3) Test Procedure
- The cross-section of the machined specimens shall be inspected for visual discontinuities.
- Each 1/16 inch (1.5 mm) wide specimen shall be placed in a clamp such that the bond line between the fitting and the pipe is located at the place of bending.
- The entire length of the bond is to be flexed 90 degrees along the plane of bending, four times in both directions. See Figure 5-6.

(4) Acceptance Criteria
- The cross-section of the machined specimens shall meet the requirement in the Visual Acceptance Criteria section in this Standard.
- Separation of the specimen along the fusion line constitutes failure of the specimen. Minor separations at the outer limits of the fusion heat source and voids between the wires are acceptable as long as the voids do not exceed the limits stated under the Visual Acceptance section of this Standard.
- Ductile failure in the pipe, fitting, or the wire insulation material is acceptable as long as the bond interface remains intact.

5-2.9.1.4 TENSILE TESTS

(a) High Speed Tensile Impact Test (HSTIT) – this test
method is designed to impart tensile impact energy to a butt-fused PE pipe specimen to evaluate its ductility.

1) Test Specimens
- Test specimens shall be removed from the butt-fused test coupon with the upset bead remaining on the outside diameter and inside diameter surfaces.
- Specimens for test coupon thicknesses less than or equal to 2 inches (50 mm) shall include the full wall thickness of the fused joint.
- Specimens for test coupons 2 inches (50 mm) and greater may be cut into approximately equal strips between 1 inch (25 mm) and 2.5 inches (64 mm) wide for testing with each segment tested individually such that the full cross section is tested.
- Test specimens shall be prepared by machining to achieve the dimensions given in Figure 5-7, with the upset beads remaining intact.
- A smooth surface free of visible flaws, scratches, or imperfections shall remain on all faces of the reduced area with no notches, gouges, or undercuts exceeding the dimensional tolerances given in ASTM F2634.
- Marks left by coarse machining operations shall be removed, and the surfaces shall be smoothed with abrasive paper (600 grit or finer) with the sanding strokes applied parallel to the longitudinal axis of the test specimen.
- Condition the test specimens at 73°F ± 4°F (23°C ± 2°C) for not less than 1 hour just prior to conducting the test.

2) Test Procedure
- Set up the machine and set the speed of testing to the rate specified in Test Conditions section.
- Pin each specimen in the clevis tooling of the testing machine, aligning the long axis of the specimen and the tooling with the pulling direction of the test machine.
- Testing shall be performed in accordance with ASTM F2634.
- Evaluate the test specimen fracture to determine the mode of failure and note the results in the test record and on the PQR.

3) Test Conditions
- Test Temperature – conduct the high-speed impact test at a temperature of 73°F ± 4°F (23°C ± 2°C) unless otherwise specified.
- Test Speed – the speed of testing shall be in accordance with Table 5-6 with a testing speed tolerance of +0.5 in./sec to -1 in/sec (+13 mm/sec to -25 mm/sec).

4) Test Record
- The HSTIT shall be documented by preparing a test record that includes the following information:
  o Testing speed applied
  o Testing temperature observed
  o Specimen dimension verification
  o Test machine clarification data
  o Test specimen identification
  o Test date
  o Test operator identification
  o Testing failure mode and acceptance or rejection
  o Test equipment identification

5) Acceptance Criteria
- Failure mode shall be ductile, with no evidence of brittle failure at the fusion interface. See Figure 5-8 for examples.

(b) Electrofusion Axial Load Resistance – this test assesses the ability of a socket type electrofusion joint to transmit axial loads.

1) Test Specimens
- Except as permitted, tensile test coupons and specimens shall be prepared and conditioned in accordance with ASTM F1055.
- Tensile tests shall be made on a complete electrofusion test assembly, not on specimen straps cut from the coupon.
- When the equipment to conduct full scale tensile tests on test coupons larger than NPS 8 (DN 200) is not available, testing for resistance to axial loads shall be conducted through one peel test plus one short-term hydrostatic pressure test for each material temperature.
- Peel Test – four specimens shall be cut at approximately 90-degree intervals from each test coupon and prepared as shown in Figure 5-9.
- Short-term Hydrostatic Test – to ensure axial forces are exerted only on the fusion joint, test coupons shall be conducted using flanged or capped pipe segments such essentially no exposed pipe protrudes outside the socket. See Figure 5-10.
water.
- The test coupon shall be pressurized using the apparatus described in ASTM D1599 to the specified pressure at a rate sufficient to achieve the full test pressure within 60 seconds.
- The test coupon shall remain under the full test pressure for a period of not less than 5 minutes.

(4) Acceptance Criteria
- Tensile Test
  - Test coupons less than or equal to NPS 8 (DN 200) shall not fail in the pipe or fitting when subjected to a tensile stress that causes the pipe to yield to an elongation of 25% or greater or cause the pipe to break outside the joint area.
  - Yielding shall be measured only in the pipe, independent of the fitting or joint.
- Peel Test
  - Specimens for sizes larger that NPS 8 (DN 200) shall not separate in the fusion interface in a brittle manner.
  - Ductile failure between wires, tearing through the coupling or pipe wall, and up to 15% separation at the outer limits of the fusion interface constitutes a failure.
- Short Term Hydrostatic Test – test coupons for sizes larger than NPS 8 (DN 200) shall not rupture or break through the fitting or fusion interface.

5.2.9.1.5 CRUSH AND IMPACT RESISTANCE TESTS

Crush tests and impact resistance tests assess the integrity of electrofusion and sidewall fusion joints.

(a) Crush Test – crush tests are used to evaluate socket-type (full wrap) or saddle-type (not full wrap) electrofusion joints. These are required for pipe sizes less than NPS 12 (DN 300) and may be used as an alternative to the electrofusion bend test for pipe sizes NPS 12 (DN 300) and greater.

(1) Test Specimens
- Socket Type – socket type joint crush test coupons shall be prepared and conditioned, and specimens removed by cutting in half longitudinally at the fusion zones in accordance with ASTM F1055.
- Saddle Type – saddle type crush test coupons shall be prepared, conditioned, and tested in accordance with ASTM F1055.

(2) Test Conditions
- The tests shall be performed at 73°F ± 4°F (23°C ± 2°C) unless otherwise specified.

(3) Test Procedure
- Socket Type – crush testing shall be performed on each end half by clamping at a distance of 1 ¼ inches (32 mm) from the outermost wires and closing the jaws until the inner walls of the pipe meet in accordance with ASTM F1055.
- Saddle Type – crush testing shall be performed by placing the jaws of a vice or hydraulic press within ½ inches (13 mm) of the edges of the saddle and tightening until the inner walls of the pipe meet in accordance with ASTM F1055.

(4) Acceptance Criteria
- Separation of the fitting from the pipe at the fusion interface constitutes a failure of the test, except that minor separation at the outermost limits of the fusion heat source up to 15% of the fusion length is acceptable.
- Ductile Failure in the pipe, fitting, or the wire insulation material, is acceptable as long as the bond interface remains intact.

(b) Impact Resistance Test – impact tests are used to evaluate saddle-type branch connection joints.

(1) Test Specimens
- Impact test specimens shall be prepared and conditioned in accordance with ASTM F1055 for electrofusion or ASTM F905 for sidewall fusion.

(2) Test Conditions
- Test Temperatures – the test shall be performed at 73°F ± 4°F (23°C ± 2°C).

(3) Test Procedure
- The joint branch connection shall be impacted in a direction parallel to the axis of the pipe with a force sufficient to break the body or other portion of the specimen.
- The test device and method of testing shall be in accordance with ASTM F905.

(4) Acceptance Criteria
- Breaking shall initiate outside of the joint area without failure of the joint.
- For electrofusion saddles, separation in the fusion interface greater than 15% of the fusion length at the outer limits of the fusion heat source constitutes failure of the test.

5.2.9.2 Tests Required for Procedure Qualifications

(a) The fusion test coupons shall be prepared in accordance with the FPS.

(b) Each fusion joint shall be subjected to a visual examination in accordance to the requirements listed in this Chapter under the applicable visual examination section.

(c) Each fusion joint shall have passed the applicable tests per the processed to be used.

(1) The employer shall document the process
and the test method used

(d) All test data shall be reviewed for compliance with the FPS requirements.

(e) The test coupons may be produced at any ambient temperature within the range specified in the FPS.

(f) If any of the tests specimens required to meet the applicable acceptance criteria, the test coupons shall be considered unacceptable.

1. When it can be determined that the cause of the failure is not related to the incorrectly selected or applied essential variables, additional tests specimens may undergo qualification testing. Another test coupon shall be prepared utilizing the original procedure specification parameters.

2. When it is has been determined that the test failure was caused by one or more incorrectly selected or applied essential variable, a new test coupon may be fused with appropriate changes to the variables that were determined to be the cause for the test failure.

3. When it is determined that the test failure was caused by one or more fusing conditions other than the essential variables, a new set of test coupons may be fused with the appropriate changes to the fusing conditions that were determined to be the cause for the previous test failure shall be addressed by the organization to ensure that the required properties are achieved in all fusion production joints.

5-2.9.2.1 Mechanical Tests

(a) High Speed Tensile Impact Test (HSTIT)

1. The specimens shall be prepared for butt fusion in accordance with the requirements in this Standard under the Tensile Test section.

2. The minimum number of specimens required to be tested shall be as follows:

   • For pipe specimens less than NPS 4 (DN 100), not less than two specimens removed from fused pipe test coupons at intervals of approximately 180 degrees apart.
   • For pipe specimens NPS 4 (DN 100) and greater, not less than four specimens removed from fused pipe test coupons at intervals approximately 90 degrees apart.
   • Other product forms, not less than two specimens removed from fused test coupons.

(b) Elevated temperature sustained pressure test results for butt fusing, sidewall fusing, and electrofusion shall be conducted in accordance with requirements listed in this Standard under Pressure Test section.

(c) Minimum hydraulic burst pressure tests for electrofusion or butt-fusing joints shall be performed in accordance with requirements listed in this Standard under Pressure Test section.

(d) Bend tests shall be performed in accordance with the requirements list in this Standard under the Bend Test section for electrofusion joints.

Electrofusion axial load resistance tests (tensile or peel plus short-term hydrostatic) shall be performed in accordance with the Standard under the Tensile Test section.

Electrofusion crush test shall be performed in accordance with the requirements in this Standard under the Crush and Impact Resistance Test section.

Electrofusion and sidewall fusion impact resistance test shall be performed in accordance with this Standard under the Crush and Impact Test section.

If any of the mechanical test specimens required fails to meet the applicable acceptance criteria, the test coupons shall be considered unacceptable.

1. When it can be determined that the cause of failure is not related to incorrectly selected or applied fusing variables, additional test specimens may be removed as close as practicable to the original specimen located to replace the failed specimens. If sufficient material is not available, another test coupon may be fused utilizing the original fusion parameters.

2. When it has been determined that the test failure was caused by one or more incorrectly selected or applied essential variables, a new test coupon may be fused with appropriate changes to the variables that were determined to be the cause for test failure.

3. When it is determined that the test failure was caused by one or more fusing conditions other than essential variables, a new set of test coupons may be fused with the appropriate changes to the fusing conditions that were determined to be the cause for the previous test failure shall be addressed by the organization to ensure that the required properties are achieved in all fused production joints.

5-2.9.2.2 Testing Procedure to Qualify the FPS

(a) Butt Fusing

1. For pipe having a wall thickness less than or equal to 2 inches (50 mm), one set of test coupons shall be prepared using any thickness of pipe less than or equal to 2 inches (50 mm) but not less one-half the thickness of the pipe to be fused in production.

2. For pipe having wall thickness greater than 2 inches (50 mm), one set of test coupons shall be prepared using pipe of a test at least 2 inches (50 mm) thickness but not less than one-half the maximum thickness to be fused in production.

3. Butt-fusing joint coupons shall be prepared in accordance with the FPS using the following combinations of heater temperature ranges and interfacial pressure ranges:

   • Higher heater surface temperatures and high interfacial pressure, five joints
   • Higher heater surface temperature and low interfacial pressure, five joints
   • Low heater surface temperature and high interfacial pressure, five joints
• Low heater surface temperature and low interfacial pressure, five joints
• Highest heater surface temperature, five joints
• Lowest heater surface temperature, five joints

(4) Each fused joint shall be subject to visual examination in accordance to the requirements listed in the Standard under the Visual Examination section.

(5) Two fused joints of each combination shall be evaluated using the elevated temperature sustained pressure tests for the for pipe specified in this Standard under the Pressure Test section.

(6) Three fused joints of each combination described in (3) shall be evaluated using the HSTIT requirements listed in this Standard.

(b) Manual Butt Fusion
(1) Manual butt fusion joints are limited to NPS 6 (DN 150) or smaller.

(2) Joint coupons shall be prepared in accordance with the FPS using the following combinations of heater temperature ranges:
• Highest heater surface temperature, five joints
• Lowest heater surface temperature, five joints

(3) When the FPS requires verification of pressure by torque, then the high pressure (verified by torque) and the low pressure (verified by torque) shall be tested at each temperature extreme.

(4) Each fused joint shall be subject to visual examination in accordance to the requirement in this Standard under the Visual Examination section.

(5) The fused joints shall be test using the hydraulic burst pressure test for pipe in accordance with the requirements in this Standard under the Pressure Test section.

(6) Failure of any test joint is cause for the test failure.

(c) Sidewall Fusing
(1) Sidewall fusing coupons shall be prepared for each design of saddle fitting base in accordance with the FPS using the specified heater temperatures and pressures.
• Successful testing shall qualify the FPS for actual heater temperature applied ±10°F (±5.5 °C) and for actual gage pressures applied ±10%.

(2) Two fused joints for each design of saddle fusing base shall be evaluated using the elevated temperature sustained pressure test in accordance to the requirements listed in this Standard under the Pressure Test section.

(3) Two fused joints for each design of saddle fusing base shall be evaluated by the sidewall fusion impact resistance test in accordance to the requirements in this Standard under the Crush and Impact Resistance section.

(d) Electrofusion
(1) Fittings shall be selected at random in the quantities shown in Table 5–7, along with the pipe segments needed for making the fused coupons, and all material shall be prepared and conditioned for a minimum of 16 hours immediately prior to fusing as follows:
• Half at the lowest material temperature to be fused in production, and half as the highest material temperature to be fused in production.
• Two low temperature coupons fused in the low temperature environment and two high temperature coupons fused in the high temperature environment are required for each of the following tests, which shall be performed at the temperatures specified in the Standard in the appropriate section:
  i. Elevated temperature sustained pressure test
  ii. Minimum hydraulic burst pressure tests
  iii. Bend test or crush test
  iv. For socket connections – axial load resistance test
  v. For saddle connections – fusion impact test, when required by contract documents.

(2) Failure of one of the four specimens tested in each test is cause for failure.
• Alternatively, four additional specimens may be produced at the failed specimen’s joining temperature and retested. Failure of any of these four additional specimens constitutes failure of the test.

5-2.9.3 Tests Required for Fusion Performance Qualifications
(a) Each fusing operator shall have passed the visual examination tests.
(b) Each fusing operator shall have passed either the mechanical or pressure test criteria.
• The employer shall document the test method used for each fusing operator.
(c) All test data shall be reviewed for compliance with the FPS requirements.
(d) Each fusing operators test coupons shall consist of fusing one pipe joint assembly in at least one of the positions shown in Figure 5-1.
(e) The test coupons may be produced at any ambient temperature within the range permitted by the FPS.

5-2.9.3.1 Visual Examination
(a) For each test coupon, all surfaces shall be examined per requirements listed in the Visual Examination section of this Standard before fusing the specimen.
(b) Test coupons shall be visually examined over the entire circumference.

5-2.9.3.2 Mechanical Tests
The mechanical test method shall be applicable to the FPS.
• For butt fusion, the test method shall follow the requirements for butt fusion coupons.
• For electrofusion, the test method shall follow the requirements for electrofusion coupons.
• For sidewall fusion, the test method shall follow the requirements for sidewall fusion coupons.

(a) One butt fusion coupon shall be prepared, from which two test specimens shall be removed from the fused test joint at intervals of approximately 180 degrees.

(b) Each specimen shall be tested by one of the following methods:

- Reverse-Bend Test – the test specimens shall be removed as shown in Figure 5-5A and 5-5B and tested in accordance with the applicable Bent Test section of this Standard.
- Guided Side-Bend Test – the test specimens shall be removed as shown in Figure 5-5A and 5-5B and tested in accordance with the applicable Bend Test section of this Standard.
- High Speed Tensile Impact Test (HSTIT) – Test specimens shall be removed, prepared, and tested in accordance to the HSTIT section of this Standard.

(c) One electrofusion coupon shall be prepared, from which either of the following tests may be performed at ambient temperature between 60°F to 80°F (16°C to 27°C):

- Electrofusion Bend Test – four electrofusion bend test specimens shall be removed in accordance with the applicable Bend Test section of this Standard.
- Crush Test – the test specimens shall be prepared in accordance with the applicable Crush Test section in this Standard.

(d) One sidewall fusion coupon shall be prepared, from which the following tests shall be performed at ambient temperature between 60°F to 80°F (16°C to 27°C):

- Reverse Bend Test – one test specimen including fusion samples from two edges of the fused saddle shall be removed in accordance with Figure 5-5A and 5-5B and tested in accordance with applicable Bend Test section in this Standard.

5-2.9.3.3 Pressure Tests

The pressure test method shall be applicable to the FPS.

- For butt and sidewall fusion, the test method shall follow the requirements for butt fusion coupons.
- For electrofusion, the test method shall follow the requirements for electrofusion coupons.

(a) One butt fusion coupon shall be prepared, from which two test specimens shall be removed from the fused test joint at intervals of approximately 180 degrees. The test specimens shall be tested in accordance with the applicable Pressure Test section in this Standard.

(b) One sidewall fusion coupon shall be prepared, from which two test specimens shall be removed from the fused test joint. The test specimens shall be tested in accordance with the applicable Pressure Test section in this Standard.

(c) One electrofusion coupon shall be prepared and shall be used as the test coupon. The test specimen shall be tested in accordance with the applicable Pressure Test section in this Standard.

5-2.9.3.4 Limits of Qualified Positions and Diameters

(a) Fusing operators who pass the required tests for butt fusing in the test positions shown in Figures 5-1 and 5-2 shall be qualified for fusing within the following limits:

- The 5G test position qualifies for the horizontal position ±45 degrees.
- The test position other than 5G qualify for the orientation tested ±20 degrees.

(b) Electrofusion operators who pass the required tests for fusing in any test position qualify for all positions.

(c) Pipe sizes within the ranges listed in Table 5-2 shall be used for test coupons to qualify within the ranges listed.

5-2.9.3.5 Retest Qualification

(a) If a fusing operator fails, the employer may retest the fusing operator.

(b) When the qualification coupon has failed the visual examination, an immediate retest is conducted. The fusing operator shall make two consecutive test coupons. If both additional test coupons pass the visual examination requirements, the examiner shall select one of the acceptable test coupons for specimen removal to facilitate conducting the required mechanical or pressure tests.

(c) When the qualification coupon has failed the mechanical or pressure test, an immediate retest is conducted. The fusing operator shall make two consecutive test coupons. If both additional coupons pass the mechanical or pressure test, the fusing operator is qualified.

5-2.9.3.6 Expiration of Qualification

(a) The performance qualification of fusing operator shall be affected when one of the following conditions occurs:

- When a fusing operator has not completed a fused joint using a qualified FPS for time period of 6 months or more, their qualification shall expire.
- When there is a specific reason to question the ability of the fusing operator to make fused joints meeting the requirements of this section, the qualifications of the fusing operator shall be revoked.

5-2.9.3.7 Renewal of Qualification
Performance qualifications that have expired under the requirements of this Standard may be renewed by having a fusing operator fuse a single test coupon and subjecting the test coupon to the testing required in this Standard. A successful test shall renew all of the fusing operator's previous qualifications for that fusing process.

(b) Fusing operator's whose qualifications have been revoked under the provisions of this Standard may be requalified by fusing a test coupon representative of the planned production work. The fused test coupon shall be tested per the requirements of this Standard. A successful test shall restore the fusing operator's qualification.

5-3 Thermoplastic Solvent Fusion Requirements

5-3.1 Scope

(a) The requirements in the Part apply to the preparation and the qualification of the procedure specification (FPS), and the performance qualifications for joining operators.

(b) Solvent cement joining of PVC to CPVC shall not be allowed in pressure piping systems. The quality of the thermoplastic joint depends on the qualification of the joiner, the material and equipment used, environmental influences, and the joiner's adherence to the FPS.

5-3.2 Procedure Qualifications

5-3.2.1 Procedure Qualification Specifications

(a) The FPS to be used for joining PVC or CPVC pipe, fittings, and components in production shall be prepared and qualified by the employer.

(b) Several FPSs may be prepared from the qualification test data recorded on a single PQR. A single PQR may encompass the range of qualified essential variables represented by multiple PQRs supporting the qualified combination and range of essential variables.

(c) The completed FPS shall address all of the essential and nonessential variables for each joining process used in the FPS. The employer may include any other information in the FPS that may be helpful in making a solvent-cement welded joint.

(d) Changes in the documented essential variables require requalification of the FPS.

(e) The employer's trade name and mark shall be shown on the qualified FPS to be used and on each procedure qualification record (PQR). In addition, the PQRs shall be signed and dated by the employer.

5-3.2.2 FPS Format

(a) The information required to be included in the FPS may be in any format, written or tabular to fit the needs of the employer, provided all the essential and nonessential variables are addressed.

5-3.3 Performance Qualifications

(a) Thermoplastic joiners shall be qualified in accordance with this the requirements in this chapter.

(b) To avoid duplication of effort, an organization may accept the performance qualification of a joiner granted by a previous employer if:

1) The previous employer's performance qualifications and procedure specifications essential variables are within the limits established in this chapter.

2) The new employer shall have a copy of the previous employer's PQR procedure that was followed during qualification. The PQR shall show the name of the employer by whom the joiner was qualified and the date of that qualification.

3) Evidence shall also be provided that the thermoplastic joiner has maintained qualification per the procedure specification, except that this evidence may be provided an employer responsible for the individual's joining performance even if not the original qualified employer.

4) The current employer's business name shall be shown on the qualification record, and it shall be signed and dated by the employer, who thereby accepts responsibility for the qualifications performed by others.

5) Owner's approval for performance qualification of joiners by others shall be documented prior to being used.

6) If the previous employer's documentation is not available, then the joiner shall be requalified.

5-3.3.1 Performance Requalification

Renewal of a bonding performance qualification is required when one of the following occurs:

(a) A joiner has not used the specific joining process for a period of 6 months or more.
There is specific reason to question the individual’s ability to make a bond that meet the FPS

5-3.2.2 Qualification Records
(a) The employer shall maintain copies of the procedure and performance qualification records specified in the Section. These copies shall be available to the owner at the location where the fabrication, assembly, and erection are being done.
(b) The employer shall be responsible for maintaining the records.
(c) The retention period for qualification records shall be 5 years after qualification.

5-3.4 Variables
(a) For each specific joining process, the joiner variables described in this chapter are applicable for the procedure qualification or requalification.
(b) For each specific joining process, the joining variables described in this chapter are applicable for the performance qualification or requalification.
(c) The joining data includes the joining variables grouped as pipe material, thermal conditions and technique.

(2) The essential and nonessential variables listed in Table 5-8 are for reference only,

5-3.4.1 Material
(a) A change in the pipe diameter beyond the range qualified in in the FPS.
(b) A change in the pipe wall thickness beyond the range qualified in the FPS.
(c) A change in the thickness or cross-sectional area to be joined beyond the range specified.
(d) A change in nominal pipe (header) diameter.

5-3.4.2 Thermal Conditions
(a) A change in the temperature range during assembly and cure period.
(b) A change in solvent cement set and cure times

5-3.4.3 Technique
(a) A change in the type or reduction in concentration of joint cleaning agent or solution.
(b) A change in the concentration of solvent cements

5-3.5 Thermoplastic Joining Using Solvent Cement
(a) Procedure
   (1) Joints shall be made with a qualified with a qualified FPS.
   (2) Preparation shall be defined in the FPS and shall specify such requirements as:
      - Cutting
      - Cleaning
      - Temperature
      - End preparation
      - Fit-up
   (3) Solvent cements for PVC and CPVC shall conform to ASTM D2564 or D2846, respectively
   (4) Cement shall be sufficient to produce a small continuous fillet of cement at the outer limits of the joints. See Figure 5-11.
   (5) The joining area shall be protected against adverse environmental conditions such as dirt, moisture, material shavings, oil, and other contaminants. Environment conditions shall be addressed in the FPS.

(b) Preparation
   (1) Preparation shall be defined in the FPS and shall specify such requirements
   (2) The surfaces to be cemented shall be cleaned. All dirt shall be removed prior to applying the solvent-cement. Cleaning may be performed by wiping with a clean cloth moistened with acetone or methylethyl ketone.
   (3) Cuts shall be free of burrs and circumferential cuts shall be as square as those obtained by the use of a saw with a miter box or a square-end sawing vise.
   (4) The interference fit shall be checked before solvent cementing. The pipe should go 1/3 to 2/3 of the of the depth of the fitting with moderate pressure.

(c) Branch Connections
   (1) For branch connections not using a tee, a manufactured full reinforcement saddle with an integral branch socket shall be solvent cemented to the pipe over its
(d) Limitations on Imperfections

(1) Imperfections exceeding the following the limitations are considered defects and shall be repaired and reexamined.
   - Protrusion of dried cement exceeding 50% of pipe wall thickness into the bore of the pipe.
   - Unfilled or unbonded areas in a joint, as indicated by the lack of interruption of the continuous fillet.

(e) Solvent Cement Materials and Equipment

(1) Fixtures and tools used in making joints shall be in such condition as to perform their function satisfactorily.

(2) Solvent cement materials that have deteriorated by exposure to air or prolonged storage, or will not spread smoothly, shall not be used in making joints.

(3) Solvent cements come in different bodies, color, and types. The employer shall use the solvent cement that is appropriate for the material and application being joined. PVC cement for PVC pipe and CPVC for CPVC pipe.

(4) Solvent cements come in regular, medium, and heavy body options. The employer shall use the solvent cement appropriate for the diameter of pipe being joined.
   - Regular and medium body cements are generally used for small pipe diameters
   - Heavy body cements are generally used for larger diameter size joints.

(5) The different solvent cements may have different storage requirements. The employer is responsible to ensure that the solvent cement storage requirement adhere to the manufacturer's requirements.

(6) Solvent cements that have exceeded their shelf life or have become discolored or gelled shall not be used.

(7) Solvent cement shall not be used near sources of heat, open flame, or when smoking.

(f) Application Process

(1) The employer shall ensure that the solvent cement used adheres to the manufacturer's requirements.

(2) Application of the solvent cement shall be performed only after preparation of the pipe has completed.

(3) The applicator used shall be adequate for the pipe diameter.
   - For smaller pipe diameters, 2 inches or less, an applicator at least ½ the size of the pipe diameter should be used.
   - For larger pipe diameters, greater than 2 inches, a natural bristle brush or roller should be used.
   - See Table 5-9 for recommended applicator sizes.

(4) If required, apply a primer prior to use of the solvent cement.
   - Primer is used to prepare the bonding area for the addition of the solvent cement and subsequent assembly.
   - A proper applicator shall be used to apply the primer. A rag should not be used.
   - The primer is applied to both the outside of the pipe end and inside of the fitting, re-dipping the applicator as necessary to ensure that the entire surface of both is tacky.
   - The solvent cement must be applied when the pipe surface is tacky.

(5) A heavy, even coat of solvent cement shall be applied to the pipe end to the depth of the socket. Leave no uncoated surface.

(6) Apply a medium coat of solvent cement to the inside of fitting, avoiding puddling of the solvent cement.
   - Puddling can cause
weakening and premature failure of the pipe or fitting.

- Apply a second coat of solvent cement as required by the manufacturer.
- Pipe sizes greater than 2 inches should receive a second coat of solvent cement on the pipe end.

(7) Assemble the parts quickly. The solvent cement must be fluid. If the solvent cement surface has started to dry, both the pipe and fitting shall be recoated.

(8) The pipe shall be fully pushed into the fitting using a 1/4 turn motion until the pipe bottoms, when possible.

- A bead of cement should be evident around the pipe and fitting juncture. If this bead is not continuous around the socket shoulder, it may indicate that insufficient solvent cement was applied. In this case, the fitting should be discarded and the joint reassembled.
- Wipe off any access solvent cement.

(9) The pipe and fitting shall be held together until the solvent cement sets to avoid pipe push out.

(10) The pipe and fitting shall be cured prior to testing.

(g) Set and Cure Times

(1) Solvent cement set and cure times are a function of pipe size, temperature, relative humidity, and tightness of fit.

(2) Drying time is faster for drier environments, smaller pipe sizes, high temperatures, and tighter fits.

(3) The assembly must be allowed to set, without any stress on the joint, per the time required by the manufacturer. See Table 5-10 for example of set times.

(4) Following the initial set period, the assembly can be handled carefully avoiding significant stresses to the joint.

(5) After a joint is assembled, the cement must be allowed to cure before the assembly is pressurized. Cure times shall be according the manufacturer's requirements. See Table 5-11 for an example of cure times.

Note: (1) Fast set solvent cements give the joiner little time to make adjustments in the position of the pipe and fitting once applied. (2) Slower PVC and CPVC solvent cements are better for large diameter applications where it takes more time to position the pipe and fittings correctly.

5-3.6 Examination and Tests

5-3.6.1 General Requirements

Results of required examinations and test shall be recorded on the procedure qualification record or the performance qualification record.

5-3.6.1.1 Visual Examination

(a) There shall be no visible evidence of exterior or interior cracks.

(b) There shall be no evidence of exterior or interior excess solvent cement.

(c) The pipe assembly shall not be loose. If it is loose, more cure time shall be required prior to visual examination.

(d) The assembly shall have no visible evidence that dirt or debris is within the solvent cement.

5-3.6.1.2 Pressure Tests

(a) Hydrostatic Pressure Test

(1) Test Coupons

- When the largest size to be joined is NPS 4 (DN 100) or smaller, the test coupon shall be the same NPS as the largest size to be joined.
- When the largest size to be joined is greater than NPS 4 (DN 100), the test coupon shall be either NPS 4 (DN 100) or a minimum of 25% of the NPS of the largest pipe component to be jointed, whichever is larger.

(2) Test Conditions
When the coupon has been appropriately cured, it shall be subjected to a hydrostatic pressure test 1.5 times the design pressure. The test pressure shall not exceed 1.5 times the maximum rated pressure of the lowest rated component in the system. The test shall be conducted so that the joint is loaded in both the circumferential and longitudinal directions.

(3) Acceptance
• The joint shall not leak or separate when tested.

5-3.6.2 Testing Required for Procedure Qualification
(a) The solvent cement test coupons shall be prepared in accordance with the FPS.
(b) The minimum number of specimens required to be tested shall be as follows:
   (1) One test coupon equal to NPS 4 (DN 200) consisting of pipe and a coupling. See Figure 5-12 for example.
   (2) One test coupon equal to NPS 4 (DN 200) consisting of a pipe and a cap.
(c) Each solvent cement joint shall be subjected to a visual examination in accordance to the requirements listed in this Standard under the applicable visual examination section.
(d) The solvent cement joint shall be subject to a hydrostatic pressure test in accordance to the requirements listed in this Standard under the applicable hydrostatic pressure test section.
(e) If any of the test specimens required fails to meet the applicable acceptance criteria, the test coupons shall be considered unacceptable.
   (1) When it can be determined that the cause of the failure is not related to the incorrectly selected or applied essential variable, a new test coupon may be fused with appropriate changes to the variables that were determined to be the cause for test failure.
   (3) When it is determined that the test failure was caused by one or more joining conditions other than essential variables, a new set of test coupons may be joined with the appropriate changes to the joining conditions that were determined to be the cause for the previous test failure shall be addressed by the organization to ensure that the required properties are achieved in all solvent cement production joints.

5-3.6.3 Testing Required for Performance Qualification
(a) Each joiner shall have passed the visual examination tests.
(b) Each joiner shall have passed the either the mechanical test or pressure test criteria.
(c) All test data shall be reviewed for compliance with the FPS requirements.
(d) Each joiner's test coupons shall consist of joining one pipe joint assembly in at least one of the of positions shown in Figure 5-12.
(e) A test coupon may be prepared at any ambient temperature within the range permitted by the FPS.
(f) One solvent cement coupon shall be prepared and undergo visual examination and pressure testing.

5-3.6.3.1 Visual Examination
(a) For each test coupon, all surfaces shall be examined per requirements listed in the Visual Examination section of this Standard before additional testing performed.
(b) Test coupons shall be visually examined over the entire circumference.

5-3.6.3.2 Pressure Tests
(a) The pressure test method shall be applicable to the FPS.
(b) The pressure test shall be performed per requirements listed in the Pressure...
Test section of this Standard.

5-3.6.3.3 Limits of Qualified Diameters

(a) Joiners who pass the required tests for solvent cement joining for pipe NPS 4 (DN 100) shall be qualified for pipe up to NPS 16 (DN400).

(b) Joiners who pass the required tests for solvent cement joining for pipe NPS 16 (DN 400) or greater shall be qualified for all sizes.

5-3.6.3.4 Retest Qualification

(a) If a joiner fails, the employer may retest the joiner.

(b) When the qualification coupon has failed the visual examination, an immediate retest is conducted. The joiner shall make two test coupons. If both additional test coupons pass the visual examination, the examiner shall select one of the acceptable test coupons for pressure testing.

(c) When the qualification coupon has failed the pressure test, an immediate retest is conducted. The joiner shall make two additional test coupons. If both test coupons pass the pressure test, the joiner is qualified.

5-3.6.3.5 Expiration of Qualification

(a) The performance qualification of a joiner shall be affected when one of the following occurs:

- When a joiner has not completed a solvent cement joint using a qualified FPS for a time period of 6 months or more, their qualification shall expire.
- When there is a specific reason to question the ability of the joiner to make solvent cement joint meeting the requirements of this chapter, the qualifications of the joiner shall be revoked.

5-3.6.3.6 Renewal of Qualification

(a) Performance qualifications that have expired under the requirements of this Standard may be renewed by having a joiner solvent cement a single joint test coupon and subjecting the test coupon to the test required in this Standard. A successful test shall renew all of the joiner’s previous qualifications for that joiner.
Tabulation of Positions in Joints

<table>
<thead>
<tr>
<th>Position</th>
<th>Diagram Reference</th>
<th>Inclination of Axis, deg</th>
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<tbody>
<tr>
<td>Horizontal</td>
<td>A</td>
<td>0 ± 45</td>
</tr>
<tr>
<td>Intermediate</td>
<td>B</td>
<td>B ± 20</td>
</tr>
<tr>
<td>Vertical</td>
<td>C</td>
<td>90 ± 20</td>
</tr>
</tbody>
</table>

GENERAL NOTE: Inclination of the axis is measured from the horizontal reference plane toward the vertical.
Figure 5-2
Fusion Test Positions

(a) Horizontal (5G)
(b) Intermediate
(c) Vertical (2G)

Figure 5-3
Heat Fusion Joints

(a) Socket Joint
(b) Butt Joint
**Figure 5-4**
Required Minimum Melt Bead Size

<table>
<thead>
<tr>
<th>Pipe (O.D.), in. (mm)</th>
<th>“A” Minimum Melt Bead Size, in. (mm)</th>
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<tbody>
<tr>
<td>&lt; 2.37 (60)</td>
<td>( \frac{1}{32} ) (1)</td>
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<td>≥ 2.37 (60) to ≤ 3.5 (89)</td>
<td>( \frac{1}{16} ) (1.5)</td>
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<tr>
<td>&gt; 3.5 (89) to ≤ 8.63 (219)</td>
<td>( \frac{5}{32} ) (5)</td>
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<tr>
<td>&gt; 8.63 (219) to ≤ 12.75 (324)</td>
<td>( \frac{1}{4} ) (6)</td>
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<td>&gt; 12.75 (324) to ≤ 24 (610)</td>
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<tr>
<td>&gt; 24 (610) to ≤ 36 (900)</td>
<td>( \frac{3}{16} ) (11)</td>
</tr>
<tr>
<td>&gt; 36 (900) to ≤ 65 (1625)</td>
<td>( \frac{7}{16} ) (14)</td>
</tr>
</tbody>
</table>
Figure 5-5A
Bend Test Specimen Removal, Configurations, and Testing (Cont'd)
Figure 5-5B
Bend Test Specimen Removal, Configurations, and Testing (Cont'd)

(e) Reverse-Bend Specimen Removal — Sidewall Fusion
Figure 5-6
Electrofusion Bend Test

(a) Socket Fusion Bend Specimens

(b) Fusion Evaluation Bend Test

(c) Saddle Fusion Bend Specimens
Figure 5-7
HSTIT Specimen Configuration and Dimensions

GENERAL NOTES:
(a) All machined surfaces 125 RMS or finer.
(b) All fractional dimensions shown are ±\(\frac{1}{64}\) in. (±1.5875 mm).
(c) All decimal dimensions are ±0.010 in. (±0.3 mm).
(d) All internal radii \(\frac{1}{8}\) in. (13 mm), external radii \(\frac{3}{8}\) in. (10 mm).
(e) Fusion bead to remain in place after machining.
Figure 5-8
HSTIT Specimen Failure Examples

(a) Brittle Rupture

(b) Ductile Rupture Outside Fusion Interface

(c) Ductile Rupture Adjacent to Fusion Interface

(d) Ductile Ruptures of Split Specimens
Figure 5-9
Electrofusion Peel Test

(a) Peel Test Sample Configuration

(b) Peel Test Loading

(c) Acceptable Peel Test Results
Figure 5-10
Short-Term Hydrostatic Test Specimen

Flanged Test Coupon

Capped Test Coupon

Figure 5-11
Solvent Fusion Joint
(a) Visually Acceptable — Uniform Bead Around Pipe

(b) Visually Acceptable — Nonuniform Bead Around Pipe, but Localized Diameter Mismatch Less Than 10% of the Nominal Wall Thickness

(c) Visually Unacceptable — V-Groove Too Deep at Pipe Tangent for Both Uniform and Nonuniform Beads
Figure 5-13B
Cross Section of Upset Beads for Sidewall Fused Fitting (Profile at Crotch of Fitting)

(a) Visually Acceptable — Similar Beads Around Fitting

(b) Visually Unacceptable — Misalignment, Overheating, or Overpressurization
(Crevice at Fitting, Abrupt Profile, Deep Ridges)

(c) Visually Unacceptable — Misalignment, Under-heating, or Under-pressurization
(Low Profile, Undefined Beads)
### Table 5-1A
Fusing Variables Procedure Specification Polyethylene Pipe Butt Fusing

<table>
<thead>
<tr>
<th>Category</th>
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<th>Essential</th>
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<tr>
<td>Joints</td>
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<td></td>
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<td></td>
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<tr>
<td>Material</td>
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<tr>
<td></td>
<td>Wall Thickness</td>
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<td></td>
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<td></td>
<td>Cross-sectional area</td>
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<td>X</td>
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<td>Thermal Conditions</td>
<td>Heater surface temperature</td>
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<td></td>
<td>Interfacial pressure</td>
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<td>X</td>
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<td></td>
<td>Decrease in melt bead width</td>
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<tr>
<td></td>
<td>Increase in heater removal time</td>
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<td></td>
<td>Decrease in cool-down time</td>
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<td>Initial heating pressure</td>
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### Table 5-1B
Fusing Variables Procedure Specification Polyethylene Pipe Electrofusion

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<td>Fit-up Gap</td>
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<td>Material</td>
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</tr>
<tr>
<td></td>
<td>Fusion voltage</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nominal fusion time</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Material temperature range</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
### Table 5-1C
Manual Butt-Fusing Variables Procedure Specification Polyethylene Pipe
Manual Butt Fusing

<table>
<thead>
<tr>
<th>Category</th>
<th>Brief of Variables</th>
<th>Essential</th>
<th>Nonessential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joints</td>
<td>Joint Type</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pipe surface alignment</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>PE Pipe</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pipe wall thickness</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cross-sectional area</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Thermal Conditions</td>
<td>Heater surface temperature</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decrease in melt bead width</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase in heater removal time</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decrease in cool down time</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>Fusing machine manufacturer</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

### Table 5-1D
Fusing Variables Procedure Specification Polyethylene Sidewall Fusing

<table>
<thead>
<tr>
<th>Category</th>
<th>Brief of Variables</th>
<th>Essential</th>
<th>Nonessential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joints</td>
<td>Joint Type</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pipe surface alignment</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>PE Pipe</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Header pipe diameter</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Thermal Conditions</td>
<td>Heater temperature</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Interfacial pressure</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Melt bead size or time</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heater plate removal time</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cool-down time</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Initial heating pressure</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td>Fusing machine manufacturer</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
### Table 5-2
Pipe Fusing Diameter Limits

<table>
<thead>
<tr>
<th>Size of Test Coupon — IPS [in. (mm)]</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Butt Fusing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 6 [6.625 (168)]</td>
<td>None</td>
<td>Size tested</td>
</tr>
<tr>
<td>6 to less than 8 [6.625 (168) to less than 8.625 (219)]</td>
<td>None</td>
<td>Less than 8 [less than 8.625 (219)]</td>
</tr>
<tr>
<td>8 to 20 [8.625 (219) to 20 (508)]</td>
<td>8 [8.625 (219)]</td>
<td>20 [20 (508)]</td>
</tr>
<tr>
<td>Greater than 20 [greater than 20 (508)]</td>
<td>Greater than 20 [greater than 20 (508)]</td>
<td>Unlimited</td>
</tr>
<tr>
<td>(b) Electrofusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than 14 [14 (356)]</td>
<td>None</td>
<td>Less than 14 [14 (356)]</td>
</tr>
<tr>
<td>14 to 24 [14 (356) to 24 (610)]</td>
<td>14 [14 (356)]</td>
<td>24 [24 (610)]</td>
</tr>
<tr>
<td>Larger than 24 [24 (610)]</td>
<td>24 [24 (610)]</td>
<td>Unlimited</td>
</tr>
<tr>
<td>(c) Manual Butt Fusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than or equal to 6 [6.625 (168)]</td>
<td>None</td>
<td>Size tested</td>
</tr>
</tbody>
</table>

### Table 5-3A
Maximum Heater Plate Removal Time for Polyethylene Butt and sidewall Fusion

<table>
<thead>
<tr>
<th>Pipe Wall Thickness, in. (mm)</th>
<th>Maximum Heater Plate Removal Time, sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Applications</td>
<td></td>
</tr>
<tr>
<td>0.17 to 0.36 (4 to 9)</td>
<td>8</td>
</tr>
<tr>
<td>&gt;0.36 to 0.55 (&gt;9 to 14)</td>
<td>10</td>
</tr>
<tr>
<td>&gt;0.55 to 1.18 (&gt;14 to 30)</td>
<td>15</td>
</tr>
<tr>
<td>&gt;1.18 to 2.5 (&gt;30 to 64)</td>
<td>20</td>
</tr>
<tr>
<td>&gt;2.5 to 4.5 (&gt;64 to 114)</td>
<td>25</td>
</tr>
<tr>
<td>&gt;4.5 (&gt;114)</td>
<td>30</td>
</tr>
<tr>
<td>Fabrication Shop</td>
<td></td>
</tr>
<tr>
<td>1.18 to 2.5 (30 to 64)</td>
<td>40</td>
</tr>
<tr>
<td>&gt;2.5 to 4.5 (&gt;64 to 114)</td>
<td>50</td>
</tr>
<tr>
<td>&gt;4.5 (&gt;114)</td>
<td>60</td>
</tr>
</tbody>
</table>
### Table 5-3B
Maximum Heater Plate Removal Time for Polypropylene Butt and Sidewall Fusion

<table>
<thead>
<tr>
<th>Pipe Wall Thickness, in. (mm)</th>
<th>Maximum Heater Plate Removal Time, sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Applications</td>
<td></td>
</tr>
<tr>
<td>&lt; 0.177 (&gt; 4.5)</td>
<td>5</td>
</tr>
<tr>
<td>&gt; 0.177 to 0.276 (&gt; 4.5 to 7)</td>
<td>6</td>
</tr>
<tr>
<td>&gt; 0.276 to 0.472 (&gt; 7 to 12)</td>
<td>7</td>
</tr>
<tr>
<td>&gt; 0.472 to 0.748 (&gt; 12 to 19)</td>
<td>9</td>
</tr>
<tr>
<td>&gt; 0.748 to 1.024 (&gt; 19 to 26)</td>
<td>11</td>
</tr>
<tr>
<td>&gt; 1.024 to 1.457 (&gt; 26 to 37)</td>
<td>14</td>
</tr>
<tr>
<td>&gt; 1.457 to 1.969 (&gt; 37 to 50)</td>
<td>17</td>
</tr>
<tr>
<td>&gt; 1.969 to 2.756 (&gt; 50 to 70)</td>
<td>22</td>
</tr>
</tbody>
</table>

### Table 5-3C
Maximum Heater Plate Removal Time for PVDF Butt Fusion

<table>
<thead>
<tr>
<th>Pipe Wall Thickness, in. (mm)</th>
<th>Maximum Heater Plate Removal Time, sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field Applications</td>
<td></td>
</tr>
<tr>
<td>0.075 to 0.217 (1.9 to 5.5)</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 0.217 to 0.591 (&gt; 5.5 to 15)</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 0.591 to 0.984 (&gt; 15 to 25)</td>
<td>5</td>
</tr>
</tbody>
</table>
### Table 5-4
Pipe Fiber Stresses - Elevated Temperature Sustained Pressure Test

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Test Pressure</th>
<th>Test Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE2708</td>
<td>580 psi (4.0 MPa)</td>
<td>1,000 hr</td>
</tr>
<tr>
<td></td>
<td>670 psi (4.6 Mpa)</td>
<td>170 hr</td>
</tr>
<tr>
<td>PE3608</td>
<td>580 psi (4.0 MPa)</td>
<td>1,000 hr</td>
</tr>
<tr>
<td></td>
<td>670 psi (4.6 Mpa)</td>
<td>170 hr</td>
</tr>
<tr>
<td>PE4710</td>
<td>660 psi (4.5 Mpa)</td>
<td>1,000 hr</td>
</tr>
<tr>
<td></td>
<td>750 psi (5.2 Mpa)</td>
<td>200 hr</td>
</tr>
</tbody>
</table>

### Table 5-5
Pipe Fiber Stresses - Minimum Hydraulic Burst Pressure

<table>
<thead>
<tr>
<th>Pipe Material</th>
<th>Test Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE2708</td>
<td>2,520 psi (17.4 MPa)</td>
</tr>
<tr>
<td>PE3608</td>
<td>2,520 psi (17.4 MPa)</td>
</tr>
<tr>
<td>PE4710</td>
<td>2,900 psi (20 Mpa)</td>
</tr>
</tbody>
</table>

### Table 5-6
Testing Speed Requirements

<table>
<thead>
<tr>
<th>Wall Thickness</th>
<th>Testing Speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 1.25 in. (32mm)</td>
<td>6 in./sec (150 mm/s)</td>
</tr>
<tr>
<td>&gt; 1.25 in. (32mm)</td>
<td>4 in./sec (150 mm/s)</td>
</tr>
</tbody>
</table>
### Table 5-7
Electrofusion Procedure Qualification Test Coupon Required

<table>
<thead>
<tr>
<th>Test Procedure</th>
<th>Conditioning and Fusing Temperature [Note (2)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Elevated Temperature Sustained Pressure Test</td>
<td>2</td>
</tr>
<tr>
<td>Minimum Hydraulic Quick Burst Pressure Test</td>
<td>2</td>
</tr>
<tr>
<td>Joint Integrity Crush Test [Note (3)]</td>
<td>2</td>
</tr>
<tr>
<td>Electrofusion Bend [Note (3)]</td>
<td>2</td>
</tr>
<tr>
<td>Electrofusion Axial Load Resistance-Tensile Peel Test</td>
<td>2</td>
</tr>
<tr>
<td>Short-term Hydrostatic</td>
<td>1</td>
</tr>
<tr>
<td>Impact Resistance [Note (4)]</td>
<td>1</td>
</tr>
</tbody>
</table>

**NOTES:**
1. Size listed is that of the branch connection.
2. Fitting manufacturer should be consulted prior to fusing outside of their recommended temperature range.
3. It is permissible to use specimens tested for the short-term hydrostatic test or minimum hydraulic quick-burst pressure test provided neither the joint area nor the pipe segment needed for crushing was a part of the failure mode in the quick-burst pressure test.
4. An impact resistance test is only required when specified in contract documents.

### Table 5-8
Joining Variables Procedure Specification Solvent Cement

<table>
<thead>
<tr>
<th>Category</th>
<th>Brief of Variables</th>
<th>Essential</th>
<th>Nonessential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material</td>
<td>PVC / CPVC Pipe</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pipe wall thickness</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pipe diameter</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Thermal Conditions</td>
<td>Atmospheric Temperature</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Set Times</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cure Times</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
### Table 5-9
**PVC/CPVC - Applicator Selection Guide**

<table>
<thead>
<tr>
<th>Applicator</th>
<th>⅛&quot;</th>
<th>⅞&quot;</th>
<th>1&quot;</th>
<th>1 ¼&quot;</th>
<th>1 ½&quot;</th>
<th>2&quot;</th>
<th>2 ½&quot; - 4&quot;</th>
<th>6&quot;-8&quot;</th>
<th>8+</th>
</tr>
</thead>
<tbody>
<tr>
<td>¾&quot; Dauber</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2&quot; Dauber</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4&quot; Dauber</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 ½&quot; Dauber</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3&quot; Roller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>4&quot; Roller</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>7&quot; Roller</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4&quot; Swab</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Note: See Manufacturer's procedures for application requirements.

### Table 5-10
**PVC/CPVC - Average Handling and Set Up Times**

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60°F - 100°F (16°C - 38°C)</td>
</tr>
<tr>
<td>⅛&quot; to 1 ⅛&quot;</td>
<td>2 minutes</td>
</tr>
<tr>
<td>1 ⅛&quot; to 2&quot;</td>
<td>5 minutes</td>
</tr>
<tr>
<td>2 ½&quot; to 4&quot;</td>
<td>15 minutes</td>
</tr>
<tr>
<td>6&quot; to 8&quot;</td>
<td>30 minutes</td>
</tr>
<tr>
<td>10&quot; to 16&quot;</td>
<td>2 hours</td>
</tr>
<tr>
<td>16&quot;+</td>
<td>4 hours</td>
</tr>
</tbody>
</table>

Note: See manufacturer's procedure for specific handling and set up times.
<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Test Pressures</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>60°F - 100°F</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(16°C - 38°C)</td>
</tr>
<tr>
<td>½&quot; to 1 ¼&quot;</td>
<td>Up to 180 psi</td>
<td>15 minutes</td>
</tr>
<tr>
<td></td>
<td>180 psi +</td>
<td>6 hours</td>
</tr>
<tr>
<td>1 ½&quot; to 2&quot;</td>
<td>Up to 180 psi</td>
<td>30 minutes</td>
</tr>
<tr>
<td></td>
<td>180 psi +</td>
<td>12 hours</td>
</tr>
<tr>
<td>2 ½&quot; to 4&quot;</td>
<td>Up to 180 psi</td>
<td>2 hours</td>
</tr>
<tr>
<td></td>
<td>180 psi +</td>
<td>16 hours</td>
</tr>
<tr>
<td>6&quot; to 8&quot;</td>
<td>Up to 180 psi</td>
<td>8 hours</td>
</tr>
<tr>
<td></td>
<td>180 psi +</td>
<td>24 hours</td>
</tr>
<tr>
<td>10&quot; to 16&quot;</td>
<td>Up to 100 psi</td>
<td>48 hours</td>
</tr>
<tr>
<td></td>
<td>100 psi +</td>
<td>Contact Solvent Cement manufacturer</td>
</tr>
<tr>
<td>16&quot;+</td>
<td>Up to 100 psi</td>
<td>72 hours</td>
</tr>
<tr>
<td></td>
<td>100 psi +</td>
<td>Contact Solvent Cement manufacturer</td>
</tr>
</tbody>
</table>

Note: See manufacturer's procedure for average cure times.
Proposal: removal of wording related to inspection in examination requirements

Rationale: Inspection by owner (or representative) would typically occur after examination

Specific Proposal

<table>
<thead>
<tr>
<th>Original</th>
<th>Proposed:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6-2.2 Examination Requirements</strong>&lt;br&gt;6-2.2.1 General. Prior to initial operation, each thermoplastic piping system installation, including components and workmanship, shall be examined in accordance with the applicable requirements of section 6-2. The type and extent of any additional examination required by engineering design, and the acceptance criteria to be applied, shall be specified. Thermoplastic joints not included in examinations required by para. 6-2.3 or by engineering design may be accepted if they pass the leak test requirements in section 6-3.&lt;br&gt;(a) Examination of thermoplastic items shall be performed after the items have passed final inspection following extrusion, injection molding, or other forming process.&lt;br&gt;(b) Examination of fabricated items shall be performed after final assembly and inspection.</td>
<td><strong>6-2.2 Examination Requirements</strong>&lt;br&gt;6-2.2.1 General. Prior to initial operation, each thermoplastic piping system installation, including components and workmanship, shall be examined in accordance with the applicable requirements of section 6-2. The type and extent of any additional examination required by engineering design, and the acceptance criteria to be applied, shall be specified. Thermoplastic joints not included in examinations required by para. 6-2.3 or by engineering design may be accepted if they pass the leak test requirements in section 6-3.&lt;br&gt;(a) Examination of thermoplastic items shall be performed after the items have passed final inspection following extrusion, injection molding, or other forming process.&lt;br&gt;(b) Examination of fabricated items shall be performed after final assembly and inspection.</td>
</tr>
</tbody>
</table>
Proposal: various changes to 6-2.3 for clarity

Rationale: The subgroup on IET feels the changes will reduce ambiguity in the current text.

Specific Proposal

<table>
<thead>
<tr>
<th>Original</th>
<th>Proposed:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6-2.3 Extent of Required Examination</strong>&lt;br&gt;Thermoplastic piping in fluid service shall be examined to the extent specified herein or to any greater extent specified in the engineering design. Acceptance criteria are as stated in para. 6-2.2.2 and in Mandatory Appendix III for fluid service.&lt;br&gt;(a) Visual Examination. At minimum, the following shall be examined in accordance with para. 6-2.7.2:&lt;br&gt;(1) sufficient materials and components, as agreed on by the owner, selected at random, to satisfy the examiner that they conform to the specifications and are free from defects.&lt;br&gt;(2) at least 5% of fabrication. For fused, solvent-welded, and adhesive joints, each operator’s or assembler’s work shall be represented and shall meet the requirements of Mandatory Appendix III. AWS G1.10 may also be used to evaluate thermoplastic welds for acceptance.&lt;br&gt;(3) random examination of the assembly of threaded, bolted, and other mechanical joints to satisfy the examiner that they conform to the applicable requirements of the engineering design.&lt;br&gt;(4) random examination of joint alignment. Pipe hangers and supports, where applicable, shall be examined to ensure spacing is at intervals per the designer’s requirements.&lt;br&gt;(5) installed thermoplastic piping and components for evidence of defects that would require replacement, and for other evident deviations from the intent of the design.&lt;br&gt;(b) Certification and Records. The examiner shall be assured by review of certifications, records, and other evidence that the thermoplastic piping components meet the requirements of the specifications. The examiner shall provide the Inspector with a certification that all of the quality control requirements of the specifications, applicable standard(s), and engineering design have been carried out.</td>
<td><strong>6-2.3 Extent of Required Examination</strong>&lt;br&gt;Thermoplastic piping intended for fluid service shall be examined to the extent specified herein or to any greater extent specified in the engineering design. Acceptance criteria are as stated in para. 6-2.2.2 and in Mandatory Appendix III for fluid service.&lt;br&gt;(a) Visual Examination. At minimum, the following shall be examined in accordance with para. 6-2.7.2:&lt;br&gt;(1) sufficient materials and components, as agreed on by the owner, selected at random, to satisfy the examiner that they conform to the specifications and are free from defects.&lt;br&gt;(2) at least 5% of fabrication, assembly, and erection. For fused, solvent-welded, and adhesive joints, each operator’s or assembler’s work shall be represented and shall meet the requirements of Mandatory Appendix III. AWS G1.10 may also be used to evaluate thermoplastic welds for acceptance.&lt;br&gt;(3) random examination of the assembly of threaded, bolted, and other mechanical joints to satisfy the examiner that they conform to the applicable requirements of the engineering design.&lt;br&gt;(4) random examination of joint alignment. Pipe hangers and supports, where applicable, shall be examined to ensure spacing is at intervals per the designer’s requirements.&lt;br&gt;(5) installed examination of erected thermoplastic piping and components system for evidence of defects that would require repair or replacement, and for other evident deviations from the intent of the design.&lt;br&gt;(b) Certification and Records. The examiner shall be assured by review of certifications, records, and other evidence that the thermoplastic piping components meet the requirements of the specifications. The examiner shall provide the Inspector with a certification that all of the quality control requirements of the specifications, applicable standard(s), and engineering design have been carried out.</td>
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</table>
**Proposal:** acceptance should follow review, and is not necessarily implied.

**Rationale:** The subgroup on IET feels the change will reduce ambiguity in the current text.

### Specific Proposal

<table>
<thead>
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<tr>
<td><strong>6-2.7.2 Visual Examination</strong>&lt;br&gt; (a) Visual examination of thermoplastic piping systems includes verification of standards, code, and engineering design requirements for&lt;br&gt; (1) materials, components, and dimensions&lt;br&gt; (2) preparation and alignment of joints&lt;br&gt; (3) alignment of materials and components&lt;br&gt; (4) method of joining, i.e., fusion, solvent welding, adhesive joining, bell-and-spigot joints, bolting, threading, etc.&lt;br&gt; (5) assembly of supports&lt;br&gt; (6) erection&lt;br&gt; (b) Visual examination shall be performed in accordance with ASME BPVC, Section V, Article 9.&lt;br&gt; (c) A joint shall receive a visual examination of all accessible pipe, fitting, and component surfaces. Acceptance criteria are as follows:&lt;br&gt; (1) There shall be no evidence of cracks, voids, inclusions, defects or flaws, lack of fusion, or incomplete joining. AWS G1.10 may be used to evaluate thermoplastic welds for acceptance. Either the designer or the owner or owner’s representative shall identify which acceptance level from AWS G1.10 is applicable.&lt;br&gt; (2) Joints shall exhibit proper design configuration.&lt;br&gt; (3) Any data record as a result of the fusing or joining process shall be reviewed and compared to design requirements.&lt;br&gt; (d) Visual examination results shall be recorded and submitted to the owner or owner's delegate on completion. The records shall include the following information:&lt;br&gt; (1) date of examination&lt;br&gt; (2) identification of piping system examined&lt;br&gt; (3) examination procedure&lt;br&gt; (4) certification of results by examiner</td>
<td><strong>6-2.7.2 Visual Examination</strong>&lt;br&gt; (a) Visual examination of thermoplastic piping systems includes verification of standards, code, and engineering design requirements for&lt;br&gt; (1) materials, components, and dimensions&lt;br&gt; (2) preparation and alignment of joints&lt;br&gt; (3) alignment of materials and components&lt;br&gt; (4) method of joining, i.e., fusion, solvent welding, adhesive joining, bell-and-spigot joints, bolting, threading, etc.&lt;br&gt; (5) assembly of supports&lt;br&gt; (6) erection&lt;br&gt; (b) Visual examination shall be performed in accordance with ASME BPVC, Section V, Article 9.&lt;br&gt; (c) A joint shall receive a visual examination of all accessible pipe, fitting, and component surfaces. Acceptance criteria are as follows:&lt;br&gt; (1) There shall be no evidence of cracks, voids, inclusions, defects or flaws, lack of fusion, or incomplete joining. AWS G1.10 may be used to evaluate thermoplastic welds for acceptance. Either the designer or the owner or owner’s representative shall identify which acceptance level from AWS G1.10 is applicable.&lt;br&gt; (2) Joints shall exhibit proper design configuration.&lt;br&gt; (3) Any data record as a result of the fusing or joining process shall be reviewed and compared to design requirements for acceptance.&lt;br&gt; (d) Visual examination results shall be recorded and submitted to the owner or owner's delegate on completion. The records shall include the following information:&lt;br&gt; (1) date of examination&lt;br&gt; (2) identification of piping system examined&lt;br&gt; (3) examination procedure&lt;br&gt; (4) certification of results by examiner</td>
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</table>
**Standard Fusing Procedure Specification (SFPS):** see **Fusing Procedure Specification (FPS).**

**stress:**
- **bolt design stress:** the design stress used to determine the required cross-sectional area of bolts in a bolted joint.
- **displacement stress:** a stress developed by the self-constraint of the structure. It must satisfy an imposed strain pattern rather than being in equilibrium with an external load. The basic characteristic of a displacement stress is that it is self-limiting. Local yielding and minor distortions can satisfy the displacement or expansion conditions. Failure from one applied stress is not to be expected. Further, the stresses calculated in this Standard are generally lower than those predicted by theory or measured in strain-gauge tests.  

**hydrostatic design basis (HDB):** selected properties of plastic piping materials to be used in accordance with ASTM D2837 to determine the hydrostatic design stress (see definition below) for the material.

**hydrostatic design stress (HDS):** the maximum continuous stress due to internal pressure to be used in the design of plastic piping, determined from the hydrostatic design basis by use of a service (design) factor.

**sustained stress:** a stress developed by an imposed loading that is necessary to satisfy the laws of equilibrium between external and internal forces and moments. The basic characteristic of a sustained stress is that it is not self-limiting. If a sustained stress exceeds the yield strength of the material through the entire thickness, the prevention of failure is entirely dependent on the strain-hardening properties of the material. A thermal stress is not classified as a sustained stress. Further, the sustained stresses calculated in this Standard are "effective" stresses and are generally lower than those predicted by theory or measured in strain-gauge tests.

**tensile test:** a method used to determine the overall strength of a given object by fitting the object between two grips, one at each end, then slowly pulling the grips in opposite directions until the object breaks. This method provides information related to the object's yield point, tensile strength, and ultimate strength.

**thermoplastic:** a plastic (polymer) that is capable of being repeatedly softened by increase of temperature and hardened by decrease of temperature.

**thermosetting plastic:** a resin and catalyst (polymer) capable of being changed into a substantially infusible or insoluble product when cured at room temperature, or by application of heat, or by chemical means.

**tube or tubing:** see **pipe.**

**ultrasonic examination:** a nondestructive method of evaluating or testing materials by introducing ultrasonic waves into, through, or onto the surface of the article being examined and determining various attributes of the material from effects on the ultrasonic waves. Also known as ultrasonic testing (UT).  

**vent:** a small opening that allows air, gas, or the like to escape piping systems or a closed space. In thermoplastic-lined metal piping, it is the method of relieving pressure between the liner and the housing caused by permeation.

**vent coupling:** an accessory added to the vent hole to enable ducting of permeates.

**visual examination:** the observation of the portion of components, joints, and other piping elements that are or can be exposed to view before, during, or after manufacture, fabrication, assembly, erection, examination, or testing.

**Welding Procedure Specification (WPS):**

(a) formal written document describing the process for joining thermoplastic piping components by fusion, which provides direction to the installer or fusion machine operator for making sound and quality production fusion joints. See also **Fusion Performance Qualification (FPQ) and Joining Procedure Specification (JPS).**

(b) formal written document that lists the parameters to be used in construction of weldments in accordance with requirements of the ASME B31 Pressure Piping Code Sections, various ASME BPVC Sections, and AWS B2.4.

**1-4 ABBREVIATIONS**

Unless otherwise noted, the abbreviations defined in **Table 1-4-1** are used in this Standard to replace lengthy phrases in the text and in the titles of standards in **Table 4-2.1-1.**

**1-5 STATUS OF APPENDICES**

Table 1-5-1 indicates for each Appendix of this Standard whether it contains requirements or guidance. See the first page of each Appendix for details.
virgin plastic: a plastic (polymer) material in the form of pellets, granules, powder, floc, or liquid that has not been subjected to use or processing other than that required for its initial manufacture.
connections for external piping: those integral parts of individual pieces of equipment that are designed for attachment of external piping.

convoluted backup ring: a unique geometric cross-sectional shape intended to increase the stiffness of a metallic or nonmetallic ring used within a thermoplastic lap-joint flange connection.

damaging to human tissues: for the purposes of this Standard, this phrase describes a fluid service in which exposure to the fluid, caused by leakage under expected operating conditions, can harm skin, eyes, or exposed mucous membranes so that irreversible damage may result unless prompt restorative measures are taken. (Restorative measures can include flushing with water or administering antidotes or medication.)

defect: a flaw (imperfection or unintentional discontinuity) of such size, shape, orientation, location, or properties as to give cause for rejection.

designer: the person or organization in responsible charge of the engineering design.

design life: duration of time used in design calculations, selected for the purpose of verifying that a replaceable or permanent component is suitable for the anticipated period of service. (Design life does not pertain to the life of a piping system because a properly maintained and protected piping system can provide service indefinitely.)

design pressure: see para. 2-1.2.2.

design temperature: see para. 2-1.2.3(e).

design temperature, minimum: see para. 2-1.2.3(b).

displacement stress range: see para. 2-2.3.3(b).

electrofusion welding (EFW): a joining process for thermoplastic materials in which heat for the welding is provided by energizing an electrically resistive coil in the weld zone.

elements: see piping elements.

employer: the owner, manufacturer, fabricator, contractor, assembler, or installer responsible for the welding, joining, and nondestructive examination (NDE) performed by their organization.

engineering design: the detailed design governing a piping system, developed from process and mechanical requirements, conforming to the requirements of this Standard, and including all necessary specifications, drawings, and supporting documents.

erection: the complete installation of a piping system in the locations and on the supports designated by the engineering design and including any field assembly, fabrication, examination, inspection, and testing of the system as required by this Standard.

examination: quality control or nondestructive testing performed by the manufacturer, fabricator, or erector to verify conformance with requirements and specifications. Examples of examination include the following:

100% examination: complete examination of all of a specified kind of item in a designated lot of piping.

random examination: complete examination of a percentage of a specified kind of item in a designated lot of piping.

spot examination: a specified partial examination of each of a specified kind of item in a designated lot of piping.

examiner: a person who performs an examination.

expansion joint: a flexible piping component or assembly that absorbs seismic, thermal, and/or terminal movement.

fabrication: the preparation of piping for assembly, including cutting, threading, grooving, forming, bending, and joining of components into subassemblies. Fabrication can be performed in the shop or in the field.

fillet weld: a weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, tee joint, or corner joint.

flammable: for the purposes of this Standard, a term used to describe a fluid that under ambient or expected operating conditions is a vapor or produces vapors that can be ignited and will continue to burn in air. The term thus can apply, depending on service conditions, to fluids defined for other purposes as flammable or combustible.

flange adapter: a thermoplastic component designed to attach to a thermoplastic pipe by solvent-cement welding or heat fusing. The component has a plain end or socket end on one side and a retaining lip on the other. It is used with a backup ring to make a thermoplastic lap-joint flange connection.

flared plastic face: sealing surface formed on a pipe spool or fitting by plastic deformation of the liner. Sometimes used synonymously with “flare.”

flow: an imperfection or unintentional discontinuity that is detectable by a nondestructive examination.

flow-fusion welding (FFW): a thermoplastic welding process for sheets or pipe where the melt is constrained during the welding process.

fluid service: a general term concerning the application of a piping system, considering the combination of fluid properties, operating conditions, and other factors that establish the basis for design of the piping system.

Category D fluid service: a fluid service in which all of the following apply:

(a) The fluid handled is nonflammable, nontoxic, and not damaging to human tissues as defined in section 1-3.

(b) The design gauge pressure does not exceed 1035 kPa (150 psi).
Proposed Changes:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition in NM.1-2018, Section 1-3 Definitions</th>
<th>Proposed Revised Definition in NM.1-2XXX, Section 1-3 Definitions</th>
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<tbody>
<tr>
<td>design temperature</td>
<td>see para. 2-1.2.3.(e).</td>
<td>See para. 2-1.2.3.</td>
</tr>
<tr>
<td>design temperature, minimum</td>
<td>see para. 2-1.2.3.(b).</td>
<td>No definition needed; delete from NM.1-2XXX, Section 1-3 Definitions</td>
</tr>
</tbody>
</table>
Chapter 2
Design

2-1 DESIGN CONDITIONS

2-1.1 General

(a) The piping capacity of many nonmetallic materials degrades under load with time. Therefore, the procurement documents shall specify a design life for the piping system.

(b) If the mechanical properties of the nonmetallic material under consideration vary or degrade with time, the mechanical properties used in design shall be consistent with the load duration and design life of the piping system. Therefore, care shall be taken in selecting the appropriate material properties for a given loading.

NOTE: The physical properties for thermoplastic materials are provided in ASME NM.3.3.

2-1.2 Pressure, Temperature, and Other Loads

2-1.2.1 General

(a) These design conditions define the pressures, temperatures, and various loads applicable to the design of thermoplastic piping systems.

(b) Piping systems shall be designed for the most severe condition of coincident pressure, temperature, and loading, except as herein stated. The most severe condition shall be that which results in the greatest required pipe wall thickness and the highest flange rating.

2-1.2.2 Pressure. All pressures referred to in this Standard are expressed in megapascals (MPa) above atmospheric pressure [MPa (gauge)] [pounds per square inch gauge (psig)], unless otherwise stated.

(a) Internal Design Pressure. The internal design pressure shall be no less than the maximum sustained operating pressure (MSOP) within the piping system, including the effects of static head.

(b) External Design Pressure. Piping subject to external pressure shall be designed for the maximum differential pressure anticipated during operating, shutdown, or test conditions.

(c) Pressure Cycling. This Standard does not explicitly address the contribution of fatigue caused by pressure cycling. Special consideration may be necessary where piping systems are subjected to pressure cycling.

2-1.2.3 Temperature

(a) All temperatures referred to in this Standard are the average material temperatures of the respective materials expressed in degrees Celsius (°C) [Fahrenheit (°F)], unless otherwise stated.

(b) The piping shall be designed for a material temperature representing the maximum sustained condition expected. The design temperature shall be assumed to be the same as the fluid temperature unless calculations or tests support the use of other data, in which case the design temperature shall not be less than the average of the fluid temperature and the outside wall temperature.

(c) Where a fluid passes through heat exchangers in series, the design temperature of the piping in each section of the system shall conform to the most severe temperature condition expected to be produced by the heat exchangers in that section of the system.

(d) For outdoor exposed pipe subjected to solar thermal heating, the evaluation of such heating effects shall be considered.

(e) Minimum material temperatures shall consider the minimum fluid temperature or minimum one-day meteorological conditions for the site.

(1) The pipe material shall not be used at a temperature below the manufacturer’s minimum temperature limit.

(2) See ASME NM.3.3, as available, for maximum and minimum design temperatures for the various materials.

2-1.2.4 Ambient Influences

(a) Cooling Effects on Pressure. Where the cooling of a fluid can reduce the pressure in the piping to below atmospheric, the piping shall be designed to withstand the external pressure, or provision shall be made to break the vacuum.

(b) Fluid Expansion Effects. Where the expansion of a fluid can increase the pressure, the piping system shall be designed to withstand the increased pressure, or provision shall be made to relieve the excess pressure.

2-1.2.5 Dynamic Effects

(a) Impact. Impact forces caused by all external and internal conditions shall be considered in the piping design. One form of internal impact force is due to the propagation of pressure waves produced by sudden
| Location       | NM.1-2018 Verbiage                                                                                                                                                                                                 | NM.1-2XXX Proposed Verbiage                                                                                                                                                                                                 |
|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Para. 2-1.2.3 (b) | The piping should be designed for a material temperature representing the maximum sustained condition expected. The design temperature shall be assumed to be ...                                                                 | The piping should be designed for a material temperature representing the maximum sustained condition of coincident temperature and pressure that will result in the greatest wall thickness. The design temperature shall be assumed to be ... |
| Para. 2-1.2.3(e)(2) | See ASME NM3.3, as available, for maximum and minimum design temperatures for the various materials.                                                                                                               | See ASME NM3.3, as available, for maximum design temperature of the various materials.                                                                                                                                     |
connections for external piping: those integral parts of individual pieces of equipment that are designed for attachment of external piping.

convoluted backup ring: a unique geometric cross-sectional shape intended to increase the stiffness of a metallic or nonmetallic ring used within a thermoplastic lap-joint flange connection.

damaging to human tissues: for the purposes of this Standard, this phrase describes a fluid service in which exposure to the fluid, caused by leakage under expected operating conditions, can harm skin, eyes, or exposed mucous membranes so that irreversible damage may result unless prompt restorative measures are taken. (Restorative measures can include flushing with water or administering antidotes or medication.)
defect: a flaw (imperfection or unintentional discontinuity) of such size, shape, orientation, location, or properties as to give cause for rejection.

designer: the person or organization in responsible charge of the engineering design.

design life: duration of time used in design calculations, selected for the purpose of verifying that a replaceable or permanent component is suitable for the anticipated period of service. (Design life does not pertain to the life of a piping system because a properly maintained and protected piping system can provide service indefinitely.)

design pressure: see para. 2-1.2.2.
design temperature: see para. 2-1.2.3(e).
discontinuity: a lack of continuity or cohesion; an interruption in the normal physical structure of material or a product.
displacement stress range: see para. 2-2.3.3(b).
electrofusion welding (EFW): a joining process for thermoplastic materials in which heat for the welding is provided by energizing an electrically resistive coil in the weld zone.
elements: see piping elements.
employer: the owner, manufacturer, fabricator, contractor, assembler, or installer responsible for the welding, joining, and nondestructive examination (NDE) performed by their organization.
enGINEERING DESIGN: the detailed design governing a piping system, developed from process and mechanical requirements, conforming to the requirements of this Standard, and including all necessary specifications, drawings, and supporting documents.
erection: the complete installation of a piping system in the locations and on the supports designated by the engineering design and including any field assembly, fabrication, examination, inspection, and testing of the system as required by this Standard.

examination: quality control or nondestructive testing performed by the manufacturer, fabricator, or erector to verify conformance with requirements and specifications. Examples of examination include the following:
100% examination: complete examination of all of a specified kind of item in a designated lot of piping.
random examination: complete examination of a percentage of a specified kind of item in a designated lot of piping.
spot examination: a specified partial examination of each of a specified kind of item in a designated lot of piping.
examiner: a person who performs an examination.
expansion joint: a flexible piping component or assembly that absorbs seismic, thermal, and/or terminal movement.
fabrication: the preparation of piping for assembly, including cutting, threading, grooving, forming, bending, and joining of components into subassemblies. Fabrication can be performed in the shop or in the field.
fillet weld: a weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, tee joint, or corner joint.
flammable: for the purposes of this Standard, a term used to describe a fluid that, under ambient or expected operating conditions, is a vapor or produces vapors that can be ignited and will continue to burn in air. The term thus can apply, depending on service conditions, to fluids defined for other purposes as flammable or combustible.
flange adapter: a thermoplastic component designed to attach to a thermoplastic pipe by solvent-cement welding or heat fusing. The component has a plain end or socket end on one side and a retaining lip on the other. It is used with a backup ring to make a thermoplastic lap-joint flange connection.
flared plastic face: sealing surface formed on a pipe spool or fitting by plastic deformation of the liner. Sometimes used synonymously with "flare."
flow: an imperfection or unintentional discontinuity that is detectable by a nondestructive examination.
flow-fusion welding (FFW): a thermoplastic welding process for sheets or pipe where the melt is constrained during the welding process.
fluid service: a general term concerning the application of a piping system, considering the combination of fluid properties, operating conditions, and other factors that establish the basis for design of the piping system.
Category D fluid service: a fluid service in which all of the following apply:
(a) The fluid handled is nonflammable, nontoxic, and not damaging to human tissues as defined in section 1-3.
(b) The design gauge pressure does not exceed 1035 kPa (150 psi).
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<td>design life</td>
<td>duration of time used in design calculations, selected for the purpose of verifying that a replaceable or permanent component is suitable for the anticipated period of service. (Design life does not pertain to the life of a piping system because a properly maintained and protected piping system can provide service indefinitely.)</td>
<td>a period of time used in design calculations equivalent to the life expectancy of the item or system projected by its designers to work within its specified parameters. (Design life does not pertain to the actual service life of the pipeline piping system because a properly maintained and protected pipeline piping system should exceed design life expectations.)</td>
</tr>
</tbody>
</table>
pipe support elements: fixtures and structural attachments as follows:
(a) Fixtures are elements that transfer the load from the pipe or structural attachment to the supporting structure or equipment. They include, but are not limited to, hanging-type fixtures, such as hanger rods including parts, spring hangers, sway braces, counterweights, turnbuckles, struts, chains, guides, anchors, and snubbers; and bearing-type fixtures, such as saddles, bases, rollers, brackets, and sliding supports.
(b) Structural attachments are elements that are bolted or clamped to the pipe, such as clips, lugs, rings, clamps, clevises, straps, and skirts.
piping: assemblies of piping components used to convey, distribute, mix, separate, discharge, meter, control, or snub fluid flows. Piping also includes pipe support elements but does not include support structures, such as building frames, bases, foundations, or any equipment excluded from this Standard [see para. 1-2.1(d)].
piping components: mechanical elements suitable for joining or assembly into pressure-tight fluid-containing piping systems. Components include pipe, piping subassemblies, tubing, fittings, flanges, gaskets, bolting, valves, and devices such as expansion joints, flexible joints, pressure hoses, traps, strainers, inline portions of instruments, and separators.
piping elements: any material or work required to plan and install a piping system. Elements of piping include design specifications, materials, components, supports, fabrication, examination, inspection, and testing.
piping installation: designed piping systems to which a selected standard edition applies.
piping system: interconnected piping and components subject to the same set or sets of design conditions.
plastic: a material that contains a variety of semisynthetic or synthetics solids (polymers), is solid in its finished state, and, at some stage in its manufacture or processing, can be shaped by flow. The two general types of plastics are thermoplastic and thermosetting plastics.
pressure: an application of force per unit area; fluid pressure (an application of internal or external fluid force per unit area on the pressure boundary of piping components).
Procedure Qualification Record (PQR): a document listing all pertinent data, including the essential variables employed and the test results, used in qualifying the procedure specification. See also Fusing Procedure Specification (FPS) and Joining Procedure Specification (JPS).
proof testing: process or method for determining design performance characteristics or quality of a component.

qualified life: the length of time for which a nonmetallic, reinforced, multilayered thermoplastic piping system has been qualified for use. [See para. 8-3.2.1(c).]
reinforcing ring: a metallic or nonmetallic ring used to distribute the load from the threaded fasteners used with thermoplastic flange adapters.
relining: a technique used to rehabilitate pipelines by pulling or inserting a pipe liner into the existing host piping system.
restraint: a device designed to prevent, resist, or limit movement of a piping system.
sealing area: the cross-sectional area of the molded or flared plastic face of thermoplastic-lined metallic piping, which has metallic backing that resists bolting stress.
sealing stress: the sustained pressure imparted by flange bolting necessary to effect a long-term leak-tight joint. It is normally less than seating stress, as long-term joint performance implies the initial seating stress has been previously applied.
seating stress: the initial pressure imparted by flange bolting necessary to effect a leak-tight seal. It is normally greater than sealing stress, due to the necessity of deforming sealing surface imperfections into the mating surface.
shall: an expression of a requirement.
should: an expression of a recommendation.
socket fusion: a fusion-joining method for assembly of certain thermoplastic fittings and pipe in which the pipe fits inside of the fitting. A metal socket mounted on a hot plate heats the outside circumference of the pipe along a defined length, which will vary depending on the size of pipe and fitting being fused. A metal spigot on the opposite side of the hot plate simultaneously heats the inside surface of the injection-molded fitting; the length of the heated region is the same as that for the pipe. Both fitting and pipe are heated for a set length of time, after which the heated socket or spigot tooling is removed and the pipe is pushed into the fitting to form a coalescent joint.
solvent-cement welding: a method for joining pipe and fittings made of certain thermoplastics [chlorinated poly(vinyl chloride) (CPVC), poly(vinyl chloride) (PVC), and acrylonitrile-butadiene-styrene (ABS)] in which a solvent cement containing chemical solvents is used, with or without primers, to dissolve the surfaces of the pipe's outer diameter and the fitting socket to fuse the surfaces together to form a pipe joint.
solvent-weld joint: a permanent bond between thermoplastic piping components formed by the use of solvent or solvent cement that forms an attachment between the mating surfaces.
Proposed Changes:

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<td>qualified life</td>
<td>the length of time for which a nonmetallic, reinforced, multilayered thermoplastic piping system has been qualified for use. [See para. 8-3.2.1(c).]</td>
<td>No definition needed; remove from Section 1-3 in NM.1-2XXX.</td>
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pipe support elements: fixtures and structural attachments as follows:

(a) Fixtures are elements that transfer the load from the pipe or structural attachment to the supporting structure or equipment. They include, but are not limited to, hanging-type fixtures, such as hanger rods including parts, spring hangers, sway braces, counterweights, turn-buckles, struts, chains, guides, anchors, and snubbers; and bearing-type fixtures, such as saddles, bases, rollers, brackets, and sliding supports.

(b) Structural attachments are elements that are bolted or clamped to the pipe, such as clips, lugs, rings, clamps, clevises, straps, and skirts.

piping: assemblies of piping components used to convey, distribute, mix, separate, discharge, meter, control, or snub fluid flows. Piping also includes pipe support elements but does not include support structures, such as building frames, bents, foundations, or any equipment excluded from this Standard [see para. 1-2.1(d)].

piping components: mechanical elements suitable for joining or assembly into pressure-tight fluid-containing piping systems. Components include pipe, piping subassemblies, tubing, fittings, flanges, gaskets, bolting, valves, and devices such as expansion joints, flexible joints, pressure hoses, traps, strainers, inline portions of instruments, and separators.

piping elements: any material or work required to plan and install a piping system. Elements of piping include design specifications, materials, components, supports, fabrication, examination, inspection, and testing.

piping installation: designed piping systems to which a selected standard edition applies.

piping system: interconnected piping and components subject to the same set or sets of design conditions.

plastic: a material that contains a variety of semisynthetic or synthetic solids (polymers), is solid in its finished state, and, at some stage in its manufacture or processing, can be shaped by flow. The two general types of plastics are thermoplastic and thermosetting plastics.

pressure: an application of force per unit area; fluid pressure (an application of internal or external fluid force per unit area on the pressure boundary of piping components).

Procedure Qualification Record (PQR): a document listing all pertinent data, including the essential variables employed and the test results, used in qualifying the procedure specification. See also Fusing Procedure Specification (FPS) and Joining Procedure Specification (JPS).

proof testing: process or method for determining design performance characteristics or quality of a component.

qualified life: the length of time for which a nonmetallic, reinforced, multilayered thermoplastic piping system has been qualified for use. [See para. 8-3.2.1(c).]

reinforcing ring: a metallic or nonmetallic ring used to distribute the load from the threaded fasteners used with thermoplastic flange adapters.

relining: a technique used to rehabilitate pipelines by pulling or inserting a pipe liner into the existing host piping system.

restraint: a device designed to prevent, resist, or limit movement of a piping system.

sealing area: the cross-sectional area of the molded or flared plastic face of thermoplastic-lined metallic piping, which has metallic backing that resists bolting stress.

sealing stress: the sustained pressure imparted by flange bolting necessary to effect a long-term leak-tight joint. It is normally less than seating stress, as long-term joint performance implies the initial seating stress has been previously applied.

seating stress: the initial pressure imparted by flange bolting necessary to effect a leak-tight seal. It is normally greater than sealing stress, due to the necessity of deforming sealing surface imperfections into the mating surface.

shall: an expression of a requirement.

should: an expression of a recommendation.

socket fusion: a fusion-joining method for assembly of certain thermoplastic fittings and pipe in which the pipe fits inside of the fitting. A metal socket mounted on a hot plate heats the outside circumference of the pipe along a defined length, which will vary depending on the size of pipe and fitting being fused. A metal spigot on the opposite side of the hot plate simultaneously heats the inside surface of the injection-molded fitting; the length of the heated region is the same as that of the pipe. Both fitting and pipe are heated for a set length after which the heated socket or spigot tooling is removed and the pipe is pushed into the fitting to form a coalescent joint.

solvent-cement welding: a method for joining pipe and fittings made of certain thermoplastics [chlorinated poly(vinyl chloride) (CPVC), poly(vinyl chloride) (PVC), acrylonitrile-butadiene-styrene (ABS)] in which a solvent cement containing chemical solvents is used, with or without primers, to dissolve the surfaces of the pipe's outer diameter and the fitting socket to fuse the surfaces together to form a pipe joint.

solvent-weld joint: a permanent bond between thermoplastic piping components formed by the use of solvent or solvent cement that forms an attachment between the mating surfaces.
Proposed Changes:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition in NM.1-2018, Section 1-3 Definitions</th>
<th>Proposed Revised Definition in NM.1-2XXX, Section 1-3 Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>solvent-cement welding</td>
<td>a method for joining pipe and fittings made of certain thermoplastics [chlorinated polyvinyl chloride (CPVC), polyvinyl chloride (PVC), and acrylonitrile–butadiene–styrene (ABS)] in which a solvent cement containing chemical solvents is used, with or without primers, to dissolve the surfaces of the pipe’s outer diameter and the fitting socket to fuse the surfaces together to form a pipe joint.</td>
<td>a permanent bond between thermoplastic piping components formed sufficiently with solvent-cement to permit the coalescence of surfaces to form a pipe joint.</td>
</tr>
<tr>
<td>solvent welding</td>
<td>No definition in NM.1-2018</td>
<td>see solvent-cement welding.</td>
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