PMG LISTING CRITERIA FOR
PP, PEX, PEX-AL-PEX, AND PP-AL-PP PIPING, TUBE AND FITTINGS
USED IN RADIANT HEATING AND WATER SUPPLY SYSTEMS

LC1004

Approved November 2009
(Editorially Revised June 2010)

PREFACE


Alternative materials, methods and equipment. The provisions of this code are not intended to prevent the installation of any material or to prohibit any method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material or method of construction shall be approved where the code official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

Similar provisions are contained in the Uniform Codes.

ICC-ES may consider alternate listing criteria, provided the listing applicant submits valid data demonstrating that the alternate listing criteria are at least equivalent to the listing criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria set forth in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria in this document and otherwise demonstrate compliance with the performance features of the codes, ICC-ES retains the right to refuse to issue or renew a listing, if the product, material, or type or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause unreasonable property damage or personal injury or sickness relative to the benefits to be achieved by the use of the product, material, or type or method of construction.

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1.0 INTRODUCTION

1.1 Purpose: The purpose of this listing criteria is to establish requirements for plastic tube and associated fittings to be recognized in an ICC Evaluation Service, Inc. (ICC-ES) listing.

1.2 Scope: This listing criteria defines test methods and performance requirements applicable to PP, PEX, PEX-AL-PEX, and PP-AL-PP tube and fittings used in radiant heating and potable water supply systems with a maximum design temperature of 180°F (82°C) at a pressure of 100 psi (689 kPa) and a maximum design pressure of 160 psi (1.1 MPa) at a temperature of 73.4°F (23°C).

1.3 Codes and Referenced Standards:

Note: Any standard referenced herein shall be the current edition of that standard. In instances where the applicable code references a different edition of a given standard, the applicant shall also provide documentation of conformance with the code referenced standard edition.


1.3.4 2009 Uniform Mechanical Code™*, Chapter 12, Hydronics. International Association of Plumbing and Mechanical Officials.


1.3.9 ASTM D 2837, Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Piping Materials, ASTM International.

1.3.10 ASTM F 876, Specification for Crosslinked Polyethylene (PEX) Tubing, ASTM International.


1.3.13 ASTM F 1807, Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring for SDR9 Crosslinked Polyethylene (PEX) Tubing, ASTM International.


1.3.15 ASTM F 1974, Specification for Metallic Insert Fittings for Polyethylene/Aluminum/Polyethylene and Crosslinked Polyethylene/Aluminum/Crosslinked Polyethylene Composite Pressure Pipe, ASTM International.


1.3.17 ASTM F 2080, Specification for Cold-Expansion Fittings with Metal Compression-Sleeves for Cross-Linked Polyethylene (PEX) Pipe, ASTM International.


1.3.19 ISO 9080, Plastics Piping and Ducting Systems—Determination of the Long-Term Hydrostatic Strength of Thermoplastic Materials in Pipe Form by Extrapolation, International Standards Organization. [This was ISO/TR 9080 prior to 2003.]
2.0 BASIC INFORMATION

2.1 Product Description: Complete information shall be provided concerning material specifications, thickness, size and the manufacturing process.

2.2 Installation Instructions: Product shall be installed in accordance with the manufacturer's instructions and the requirements of the applicable codes and reference standards in Section 1.3.

2.3 Packaging and Identification: The unit and the package shall be permanently and legibly marked with the manufacturer's name or trademark, and the model number. The product shall also bear the PMG® listing mark. The ICC-ES listing number shall be placed on the listed product's packaging or installation instructions.

3.0 GENERAL REQUIREMENTS

3.1 Fittings and Assembly: Tests shall be conducted using fittings that will be recognized in the evaluation report for use with the tube. Test specimens shall be assembled in accordance with the manufacturer’s recommended methods.

3.2 Test Conditioning: Test specimens shall be conditioned at 73.4°F ± 3.6°F (23°C ± 2°C) and 50 ± 5 percent relative humidity for not less than 40 hours prior to test, unless otherwise specified in this criteria.

3.3 Basic Short-term Properties: Tube and fittings shall comply with the appropriate standard(s) listed below:

3.3.1 Polypropylene (PP) Pipe and Fitting Systems: ASTM F 2389.

3.3.2 Crosslinked Polyethylene (PEX) Tube and Fittings: ASTM F 876 and ASTM F 877.
3.3.3 Crosslinked Polyethylene/Aluminum/ Crosslinked Polyethylene (PEX-AL-PEX) Pipe and Fittings: ASTM F 1281.

3.3.4 Polypropylene-Aluminum-Polypropylene (PP-AL-PP) Pipe and Polypropylene Fittings Systems:

3.3.4.1 Materials, General:

3.3.4.1.1 Shall be shown to meet the requirements of Sections 5 and 6 of ASTM F 2389.

3.3.4.1.2 Shall be shown to satisfy Sections 8.1, 8.2 and 8.3 of ASTM F 2389.

3.3.4.1.3 Aluminum shall have physical properties as required by Section 5.2 of ASTM F 1281, substituting Table 3 of AC122 for Table 1 of ASTM F 1281.

3.3.4.2 Adhesive polymer shall be shown to:

3.3.4.2.1 Satisfy Sections 6.3 and 6.4 in accordance with Sections 9.3 and 9.4 of ASTM F 1281, substituting Table 2 of AC122 for Table 3 of ASTM F 1281.

3.3.4.2.2 Demonstrate a Vicat Softening Point equal to or exceeding 110°C when tested in accordance with ASTM D 1525.

3.3.4.2.3 Demonstrate a density less than or equal to 0.95 g/cm³ when tested in accordance with ASTM D 1505.

3.3.4.3 Pipe dimensions shall be in conformance with Section 6.1 of ASTM F 1986, substituting Table 3 of AC122 for Table 1 of ASTM F 1986.

3.3.4.4 Pipe and fittings shall demonstrate conformance with the test requirements noted in Section 8 of ASTM F 1986, excluding Section 8.6 “gel content,” and substituting Table 1 of AC122 for Table 4 of ASTM F 1986, for delamination testing.

3.3.4.5 Minimum burst pressure test shall be in conformance with Section 6.3 of ASTM F 1986, with the pipe and fittings assembled in accordance with the manufacturer’s installation instructions. Substitute Table 2 of AC122 for Table 5 of ASTM F 1986.

3.3.4.6 Sustained pressure tests shall be in conformance with Section 6.6 of ASTM F 1281.

3.3.4.7 Pipe marking shall include the following:
3.3.4.7.1 Nominal pipe size and wall thickness.
3.3.4.7.2 Report holder’s name.
3.3.4.7.3 Material designation: PP/AL/PP.
3.3.4.7.4 Production code.
3.3.4.7.5 Evaluation report number.
3.3.4.7.6 Name or logo of the inspection agency.
3.3.4.7.7 Potable water designation.
3.3.4.8 Fitting marking shall include the following:
3.3.4.8.1 Nominal size.
3.3.4.8.2 Material designation.
3.3.4.8.3 Report holder’s name.
3.3.4.8.4 Potable water designation.

4.0 TEST METHOD AND PERFORMANCE REQUIREMENTS

4.1 Hydrostatic Design Basis:

4.1.1 Polypropylene: The long-term hydrostatic strength of the piping shall be determined in accordance with the requirements of ASTM F 2389 and testing in accordance with ISO 9080, and extrapolated to 50 years (438,000 hours) at 73.4°F (23°C) and 180°F (82°C). Condition of acceptance for recognition as a water distribution system is that pipe and fittings shall be rated for a minimum of 100 psi (689 kPa) pressure at a temperature of 180°F (82°C). Condition of acceptance for recognition as a water service system is that pipe and fittings shall have a minimum pressure rating of 160 psi (1.1 MPa) at a temperature of 73.4°F (23°C).

4.1.2 Cross-linked Polyethylene: The hydrostatic design basis of the tube shall be determined in accordance with the requirements of PPI Technical Report TR-3 for standard grades at 180°F (82°C), following the methods of ASTM D 2837. Copies of PPI TR-3 may be obtained from the Plastic Pipe Institute, A Division of the Society of the Plastics Industry, Inc., 1825 Connecticut Avenue NW, Suite 680, Washington, DC 20009.
The rated pressure of the tube is calculated as follows:

\[ P = \frac{2(DF)(HDB)}{(D_o \cdot t - 1)} \]

where:
- \( P \) = Rated pressure, psi.
- \( DF \) = Design factor = 0.50.
- \( HDB \) = Hydrostatic design basis, psi.
- \( D_o \) = Outside diameter of tube, inches.
- \( t \) = Thickness of tube, inches.

Condition of acceptance for recognition as a water distribution system is that tube and fittings shall be rated for a minimum of 100 psi (689 kPa) pressure at a temperature of 180°F (82°C). Condition of acceptance for recognition as a water service system is that tube and fittings shall have a minimum pressure rating of 160 psi (1.1 MPa) at 73.4°F (23°C).

**Exception:** For PEX products crosslinked by peroxides, Azo compounds in extrusion, or electron beams after extrusion or silane method, the hydrostatic design basis may be determined in accordance with PPI Technical Report TR-3 for experimental grades at 180°F (82°C), provided the requirements of the standard grade at 180°F (82°C) are met, and data is submitted to ICC-ES, within the period of time specified in PPI TR-3.

4.1.3 **PEX-AL-PEX:** PEX-AL-PEX tube shall have a pressure design basis (PDB) established in accordance with the requirements of PPI Technical Report TR-3 at 180°F (82°C), following the method of ASTM D 2837, with the following exceptions: Test pressure versus time shall be plotted following the methods of ASTM D 2837 and shall be extrapolated to 100,000 hours. The hydrostatic pressure basis shall be the pressure corresponding to 100,000 hours on the straight-line plot. The rated pressure of the tube shall be calculated as follows:

\[ P = PDB(DF) \]

where:
- \( P \) = Rated pressure, psi.
- \( PDB \) = Pressure design basis, psi.
- \( DF \) = Design factor = 0.50.
The hydrostatic pressure basis must be established for all tube sizes for which recognition is sought. Alternate test proposals may be considered with written concurrence of ICC-ES. Condition of acceptance for recognition as a water distribution system is that tube and fittings shall be rated for a minimum of 100 psi (689 kPa) pressure at a temperature of 180°F (82°C). Condition of acceptance for recognition as a water service system is that tube and fittings shall have a minimum pressure rating of 160 psi (1.1 MPa) at 73.4°F (23°C).

**Exception:** For PEX-AL-PEX products, the hydrostatic PDB may be determined in accordance with PPI Technical Report TR-3/92 for experimental grades at 180°F (82°C), provided the requirements of the standard grade at 180°F (82°C) are met, and data is submitted to ICC-ES, within the period of time specified in PPI TR-3.

4.1.4 **PP-AL-PP:** The long-term hydrostatic strength of each size of the piping shall be determined in accordance with the requirements of ASTM D 2387 and testing in accordance with ISO 9080, and extrapolated to 50 years (438,000 hours) at 73.4°F (23°C) and 180°F (82°C). Condition of acceptance for recognition as a water distribution system is that pipe and fittings shall be rated for a minimum of 100 psi (689 kPa) pressure at a temperature of 180°F (82°C). Condition of acceptance for recognition as a water service system is that pipe and fittings shall have a minimum pressure rating of 160 psi (1.1 MPa) at a temperature of 73.4°F (23°C).

4.1.5 **Source of Hydrostatic Design Basis:** For PEX products, the requirements for reports of tests for hydrostatic design basis in accordance with Section 3.3 may be satisfied by submission of reports of tests conducted by the resin or compound manufacturer. The crosslinking process used by the compound manufacturer in producing PEX tubing for testing must be representative of the crosslinking process used by the tubing manufacturer.

4.2 **Potable Water Systems:** Tube and fittings for use in potable water systems shall comply with the requirements of NSF 61.
4.3 Fittings:

4.3.1 Tubing is recognized for use with fittings only as determined by testing in accordance with this criteria, except as noted in Sections 4.3.2 and 4.3.3. The quality control manual shall document fitting tolerances compatible with recognized tubing.

4.3.2 PEX-AL-PEX tube complying with ASTM F 1281 may also be recognized for installation with fittings complying with ASTM F 1974, provided fittings are recognized in a current ICC-ES evaluation report.

4.3.3 PEX tube complying with ASTM F 876 may be recognized for installation with fittings complying with ASTM F 1807, ASTM F 1960, ASSE 1061, AC311 or ASTM F 2080, provided fittings are recognized in a current ICC-ES evaluation report. Tubing to be used with fittings complying with ASSE 1061 or AC311 shall be marked with the standard designation “ASSE 1061.”

4.3.4 PP-AL-PP tube complying with Section 3.2.4 may be recognized for installation with fittings complying with ASTM F1986 or F 2389, provided fittings are recognized in a current ICC-ES evaluation report.

Exception: The fitting dimensions shall conform to Table 4.

5.0 LISTING RECOGNITION CONDITIONS

5.1 Radiant Systems Using Fluids Other Than Potable Water: Piping and fittings successfully tested in accordance with Sections 3.1, 3.2, 3.3 and 3.5, with water, may be recognized for use in radiant systems using fluids other than water when the requirements of this section are satisfied.

5.1.1 Polypropylene (PP) and Polypropylene- Aluminum-Polypropylene (PP-AL-PP) Pipe and Fitting Systems: PP pipe and fittings used in radiant heating systems with aqueous solutions of propylene glycol or ethylene glycol shall satisfy this section.

5.1.1.1 Hydrostatic Testing: Testing shall be conducted for each glycol fluid for which recognition is sought. Test assemblies shall be in accordance with Section 9.1 of ASTM F 2389 and shall be filled with a 100 percent glycol solution. The assemblies shall be subjected to the 1-hour and the 1000-
hour tests as specified in Section 8.5 of ASTM F 2389, and shall satisfy the criteria therein. During testing, a means shall be provided to ensure the glycol heat transfer fluid does not migrate out of the test specimen and into the water pressure source.

5.1.1.2 **Tensile Strength and Weight Change:** Tensile strength and weight change shall be evaluated on six specimens of tubing and fittings in accordance with ASTM D 543 at 95°C (203°F), using 100 percent concentration of each glycol heat transfer fluid for which recognition is sought. The sample shall exhibit a maximum 10 percent change in tensile strength and a maximum 0.5 percent weight change.

5.2 **Nonpotable Water Piping or Heat Transfer Fluid:** Radiant heating systems using plastic pipe and fittings which are not approved for use in potable water distribution systems, or for systems using heat transfer fluids other than potable water, shall not be connected to the potable water, except through the use of approved devices such as backflow preventers or double-walled heat exchangers.

5.3 **Radiant System with a Nonpotable Heat Transfer Fluid:** In the case of plastic pipe and fittings tested and found to be acceptable for use in radiant heating systems with a heat transfer fluid other than potable water, the alternate fluid shall be identified in the evaluation report.

5.4 **Cell Classification:** Cell classification and density shall be documented in the quality control manual.

5.5 **Oxygen-diffusion Barriers and Hydrostatic Testing:** For PEX tubing with oxygen-diffusion barrier coatings, the barrier material is not considered a structural coating for the purpose of hydrostatic tests. Uncoated base tubing shall meet the minimum requirements as set forth in Sections 3.1, 3.2, 3.3 and 4.1. Tests shall confirm that the barrier coating does not diminish the pressure capability of the tube. Dimensions and tolerances for coated tube shall be compatible with specified fittings.

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### TABLE 1—DELAMINATION TOOL DIMENSIONS

<table>
<thead>
<tr>
<th>PIPE NOMINAL SIZE (mm)</th>
<th>TOOLING MEASUREMENTS</th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dimension (mm)</td>
<td>dimension (inches) A</td>
<td>B</td>
<td>C</td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0.630</td>
<td>11.5</td>
<td>0.453</td>
<td>14.1</td>
<td>0.555</td>
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<td>13.5</td>
<td>0.531</td>
<td>16.3</td>
<td>0.643</td>
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<td>21</td>
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<td>16.5</td>
<td>0.650</td>
<td>20.0</td>
<td>0.786</td>
</tr>
<tr>
<td>26</td>
<td>1.024</td>
<td>21.5</td>
<td>0.846</td>
<td>25.5</td>
<td>1.004</td>
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<tr>
<td>32</td>
<td>1.260</td>
<td>27.5</td>
<td>1.083</td>
<td>31.9</td>
<td>1.256</td>
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<tr>
<td>40</td>
<td>1.575</td>
<td>33.5</td>
<td>1.319</td>
<td>38.7</td>
<td>1.524</td>
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<tr>
<td>50</td>
<td>1.969</td>
<td>43.5</td>
<td>1.713</td>
<td>49.8</td>
<td>1.961</td>
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<tr>
<td>63</td>
<td>2.480</td>
<td>56.5</td>
<td>2.224</td>
<td>64.2</td>
<td>2.528</td>
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### TABLE 2—BURST PRESSURE TEST FOR MULTILAYER PIPE AND SOCKET-FUSION FITTINGS/MINIMUM PIPE RING STRENGTHS/MINIMUM ADHESIVE FORCE FOR COMPOSITE PIPE

<table>
<thead>
<tr>
<th>PIPE DIAMETER (mm)</th>
<th>MINIMUM BURST PRESSURE AT 20°F (68°F)</th>
<th>MINIMUM PIPE RING STRENGTH</th>
<th>MINIMUM ADHESIVE FORCE PER 10 mm (0.394 inch) PIPE STRIP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kPa</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>(psi)</td>
<td>(lbs)</td>
<td>(lbs)</td>
</tr>
<tr>
<td>16</td>
<td>8,000</td>
<td>2,300</td>
<td>515</td>
</tr>
<tr>
<td>18</td>
<td>8,000</td>
<td>2,500</td>
<td>560</td>
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<tr>
<td>21</td>
<td>7,000</td>
<td>2,500</td>
<td>560</td>
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<td>26</td>
<td>7,000</td>
<td>2,500</td>
<td>560</td>
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<tr>
<td>32</td>
<td>6,000</td>
<td>2,500</td>
<td>560</td>
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<tr>
<td>40</td>
<td>6,000</td>
<td>2,500</td>
<td>560</td>
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<tr>
<td>50</td>
<td>6,000</td>
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<td>560</td>
</tr>
<tr>
<td>63</td>
<td>5,000</td>
<td>2,500</td>
<td>560</td>
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### TABLE 3—PHYSICAL DIMENSIONS OF PIPING

<table>
<thead>
<tr>
<th>$d_i$ (inches)</th>
<th>dem</th>
<th>dim (mm)$^1$</th>
<th>MINIMUM ALUMINUM THICKNESS (mm)$^2$</th>
<th>MINIMUM THICKNESS OF PP-R LAYERS (mm)$^2$</th>
<th>OUT OF ROUNDNESS MINIMUM INSIDE DIAMETER (mm)</th>
<th>WALL THICKNESS, min, $e_{\text{min}}$ (mm)$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min. (mm)</td>
<td>Max. (mm)</td>
<td>Series S</td>
<td>Inside Layer</td>
<td>Outside Layer</td>
<td>34.5 $\leq S \leq$ 42.8</td>
</tr>
<tr>
<td>0.630</td>
<td>16</td>
<td>16.3</td>
<td>12</td>
<td>0.2</td>
<td>0.3</td>
<td>26</td>
</tr>
<tr>
<td>0.709</td>
<td>18</td>
<td>18.3</td>
<td>14</td>
<td>0.25</td>
<td>0.35</td>
<td>0.45</td>
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<tr>
<td>0.827</td>
<td>21</td>
<td>21.3</td>
<td>17</td>
<td>0.25</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>1.024</td>
<td>26</td>
<td>26.3</td>
<td>22</td>
<td>0.3</td>
<td>0.5</td>
<td>0.65</td>
</tr>
<tr>
<td>1.260</td>
<td>32</td>
<td>32.3</td>
<td>26</td>
<td>0.35</td>
<td>0.7</td>
<td>0.8</td>
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<tr>
<td>1.575</td>
<td>40</td>
<td>40.4</td>
<td>43</td>
<td>0.35</td>
<td>0.95</td>
<td>1.2</td>
</tr>
<tr>
<td>1.969</td>
<td>50</td>
<td>50.5</td>
<td>55</td>
<td>0.6</td>
<td>1.2</td>
<td>1.5</td>
</tr>
<tr>
<td>2.480</td>
<td>63</td>
<td>63.6</td>
<td>55</td>
<td>0.6</td>
<td>1.2</td>
<td>1.5</td>
</tr>
</tbody>
</table>

1. Minimum aluminum thickness shall be 0.2 mm regardless of Pipe S series.
2. Aluminum layer Series S = ($d_i - e_{ax}$) / 2 where $d_i$ is nominal diameter in millimeters and $e_{ax}$ is the minimum thickness of the aluminum layer in millimeters.
3. Tolerances on wall thickness of pipes is based on wall thickness as shown in Table 3A.
4. dim is the inner maximum diameter.
**TABLE 3A—TOLERANCES FOR WALL THICKNESS**

<table>
<thead>
<tr>
<th>WALL THICKNESS “e” (mm)</th>
<th>1.0 ≤ e ≤ 2.0</th>
<th>2.0 ≤ e ≤ 3.0</th>
<th>3.0 ≤ e ≤ 4.0</th>
<th>4.0 ≤ e ≤ 5.0</th>
<th>5.0 ≤ e ≤ 6.0</th>
<th>6.0 ≤ e ≤ 7.0</th>
<th>7.0 ≤ e ≤ 8.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOLERANCE</td>
<td>0.4 mm</td>
<td>0.5 mm</td>
<td>0.6 mm</td>
<td>0.7 mm</td>
<td>0.8 mm</td>
<td>0.9 mm</td>
<td>1.0 mm</td>
</tr>
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</table>

**TABLE 4—FITTING DIMENSIONS**

<table>
<thead>
<tr>
<th>NOMINAL SIZE</th>
<th>SOCKET ENTRANCE A</th>
<th>SOCKET BOTTOM B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Diameter</td>
<td>Tolerance on Average Diameter</td>
</tr>
<tr>
<td></td>
<td>in.</td>
<td>mm</td>
</tr>
<tr>
<td>0.630</td>
<td>16</td>
<td>0.701</td>
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<tr>
<td>0.709</td>
<td>18</td>
<td>0.791</td>
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<tr>
<td>0.827</td>
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<td>0.925</td>
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<tr>
<td>1.024</td>
<td>26</td>
<td>1.154</td>
</tr>
</tbody>
</table>

See Figure 1.

**FIGURE 1—SOCKET DIMENSION SYMBOLS**