Design Standard

Underground Piping Installations

PART 1 GENERAL

Texas A&M University requires the use of Extra High Molecular Weight (EHMW Plus) High Density Polyethylene (HDPE) pipe for potable water conveyance, chilled water (CHW) systems and sanitary sewer systems. For heating hot water (HHW) and Domestic Hot Water (DHW) systems, ductile iron or HDPE manufactured with the DOW INTREPID 2499 NT resin per the specification in Appendix A are acceptable. Specifications for HDPE and ductile iron pipe are contained in Appendices B and C respectively. Any deviations from these specifications must be approved in writing by the UES Manager for Engineering and Project Management.

For campus buildings served by TAMU central thermal distribution systems, supply and return lines typically have piping with identical size and material for each system - chilled water (CHW), heating hot water (HHW), and domestic hot water (DHW). Because these thermal distribution lines are identical in size and appearance for each thermal system, there is the potential for cross-connection between supply and return. To avoid possible cross-connection of supply and return lines, design engineers shall require field verification in construction documents and contractors shall field verify the configuration of supply and return lines, using an appropriate temperature sensing device and adequate system flow, before making building connections. Any discrepancy between construction documents and field verification should be promptly reported to the project A/E and the Owner's representative before completing piping installation, so proper piping configuration can be verified.

An isolation valve shall be installed on any lateral feeding a building so that the building can be isolated without bringing down adjacent buildings. The valve shall be a direct buried gate valve.

Victaulic products for HDPE pipe may be used only as a replacement for necessary flanges not as replacement for fusion in pipe runs that can be fused. HDPE products are rated to pressures equal to the pipe with which they are used. (The pipe manufacturer's listing is dependent upon wall thickness, pipe composition and temperature.) Victaulic couplings, transition couplings, and pipe flange adaptors may be used. Where possible use Victaulic installation-ready design which permits direct "stab" installation without prior disassembly of the couplings. Gaskets shall be molded and produced by the coupling manufacturer and suitable for intended service. Assembly of HDPE couplings and flange adapters shall be in accordance with latest published specifications.

Mineral powder insulation and pre-insulated pipe are acceptable. See the Underground Piping System Insulation Design Standard for insulation requirements.
APPENDIX A
INTREPID 2499 NT TECHNICAL INFORMATION
INTREPID™ 2499 NT
Bimodal Polyethylene Resin

Overview
INTREPID™ 2499 NT Bimodal Polyethylene Resin is a Polyethylene resin produced using UNIPOL II process technology. This product is intended for use in industrial piping systems where extreme conditions such as high temperatures, aggressive chemicals, hydrocarbons, or highly oxidative conditions exist. Suitable uses include oil and gas field pipelines, gas distribution pipelines, and other industrial applications.

Industrial Standards Compliance:
ASTM D 3350: cell classification PE445574A
Plastics Pipe Institute (PPI): TR-4
  • Natural Pipe INTREPID™ 2499 NT Bimodal Polyethylene Resin
    • ASTM PE4710 pipe grade - 1600psi HDB @ 73 °F (23°C)
    • ASTM PE4710 pipe grade - 800psi HDB @ 180 °F (82.2°C)

Additive
  • Antblock: No
  • Slip: No
  • Processing Aid: Yes

Physical

<table>
<thead>
<tr>
<th>Property</th>
<th>Nominal Value (English)</th>
<th>Nominal Value (SI)</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (Natural)</td>
<td>0.950 g/cm³</td>
<td>0.950 g/cm³</td>
<td>ASTM D792</td>
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<tr>
<td>Melt Mass-Flow Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>190°C/2.16 kg</td>
<td>0.10 g/10 min</td>
<td>0.10 g/10 min</td>
<td>ASTM D1238</td>
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<tr>
<td>190°C/21.6 kg</td>
<td>7.0 g/10 min</td>
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Mechanical

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</thead>
<tbody>
<tr>
<td>Tensile Strength (Yield)</td>
<td>&gt; 3500 psi</td>
<td>&gt; 24.1 MPa</td>
<td>ASTM D638</td>
</tr>
<tr>
<td>Tensile Elongation (Break)</td>
<td>&gt; 500 %</td>
<td>&gt; 500 %</td>
<td>ASTM D638</td>
</tr>
<tr>
<td>Flexural Modulus</td>
<td>152000 psi</td>
<td>1050 MPa</td>
<td>ASTM D790B</td>
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</tbody>
</table>

Resistance to Rapid Crack Propagation, P<sub>c</sub> - S-4
32°F (0°C) > 174 psi > 12.0 bar

Resistance to Rapid Crack Propagation, T<sub>c</sub> - S-4 @ 145 psi (10 bar) < 2 °F < -17 °C

Slow Crack Growth PENT - @ 2.4 MPa

<table>
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<tr>
<th>Temperature</th>
<th>Nominal Value (English)</th>
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<td>176°F (80°C)</td>
<td>&gt; 10000 hr</td>
<td>&gt; 10000 hr</td>
<td>ASTM F1473</td>
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<tr>
<td>194°F (90°C)</td>
<td>&gt; 10000 hr</td>
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Impact

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<th>Property</th>
<th>Nominal Value (English)</th>
<th>Nominal Value (SI)</th>
<th>Test Method</th>
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<tbody>
<tr>
<td>Notched Izod Impact (73°F (23°C))</td>
<td>9.1 ft lb/in</td>
<td>490 J/m</td>
<td>ASTM D256A</td>
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Thermal

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<tr>
<th>Property</th>
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<th>Nominal Value (SI)</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brittleness Temperature</td>
<td>&lt; -103 °F</td>
<td>&lt; -75.0 °C</td>
<td>ASTM D746A</td>
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<tr>
<td>Melting Temperature (DSC)</td>
<td>269 °F</td>
<td>132 °C</td>
<td>Dow Method</td>
</tr>
<tr>
<td>Thermal Stability</td>
<td>&gt; 428 °F</td>
<td>&gt; 220 °C</td>
<td>ASTM D3350</td>
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</tbody>
</table>

Extrusion Notes

Fabrication Conditions:
  • Screw Type: High quality HDPE barrier with mixing
  • Melt Temperature Range: 380-450°F (193-232°C)

Notes

These are typical properties only and are not to be construed as specifications. Users should confirm results by their own tests.

1 Compression molded parts prepared according to ASTM D 1928 Procedure C. Properties will vary with changes in molding conditions and aging time.

2 Method I (3 point load)

3 Pipe diameter of 10 inch IPS (25.4 cm) and Standard Diameter Ratio (SDR) 11.
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North America
U.S. & Canada: 1-800-441-4369
1-989-832-1426

Mexico: +1-800-441-4369

Latin America
Argentina: +54-11-4319-0100
Brazil: +55-11-5188-9000
Colombia: +57-1-219-6000

Mexico: +52-55-520-14700

Europe/Middle East

1-800-441-4369

Italy: +800-783-825

+31-11567-2626

South Africa

+800-99-5078

Asia Pacific

+800-7776-7776

+603-7965-5392

www.dowplastics.com

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Published: 2012-07-11

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APPENDIX B
High Density Polyethylene (HDPE) Pipe and Fittings
Appendix B

High Density Polyethylene (HDPE) Pipe and Fittings

PART 1 - GENERAL

1.1 SUMMARY

A. The Contractor shall provide all labor, equipment and materials to install High Density Polyethylene (HDPE) pipe for potable water conveyance, chilled water (CHW) systems, heating hot water (HHW) systems, and sanitary sewer by open cut and trenchless methods as Specified and shown on the Drawings. Pipe materials for HHW systems shall be ductile iron or HDPE. If noted in the Contract Documents, the Owner may provide the pipe material.

B. Related Specification Sections to be provided by Owner and/or Engineer include, but are not necessarily limited to:

1. Bidding Requirements, Contract Forms, and Conditions of the Contract
2. General Requirements
3. Cleaning and Acceptance Testing of Water Mains
4. Guided Auger Boring
5. Contact Grouting
6. Compression Fit HDPE Pipe Lining
7. Horizontal Directional Drilling (HDD)
8. Bolts, Nuts, and Gaskets

1.2 REFERENCES

A. Reference Standards:

1. Reference standards cited in this Specification refer to the current reference standard published at the time of the latest revision date logged at the end of this Specification, unless a date is specifically cited.

2. ASTM International (ASTM):
   c. D2321: Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
   d. D2657: Standard Practice for Heat-Joining Polyolefin Pipe and Fittings
   e. D2683: Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
f. D2737: Standard Specification for Polyethylene (PE) Plastic Tubing
g. D2774: Standard Recommended Practice for Underground Installation of Thermoplastic Pressure Piping
h. D3261: Butt Heat Fusion Polyethylene (PE) Plastic Fittings for PE Plastic Pipe and Tubing
i. D3035: Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
j. D3350: Standard Specifications for Polyethylene Plastic Pipe and Fitting Materials
k. F585: Standard Guide for Insertion of Flexible Polyethylene Pipe Into Existing Sewers
l. F714: Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
m. F905: Standard Practice for Qualification of Polyethylene Saddle-Fused Joints
n. F1055: Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polethylene (PEX) Pipe
o. F1290: Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings
q. F1962: Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit under Obstacles, Including River Crossings
s. F2206: Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE) Plastic Pipe, Fittings, Sheet Stock, Plate Stock, or Block Stock
t. F2321: Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
u. F2620: Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
w. F2880: Standard Specification for Lap-Joint Type Flange Adapters for Polyethylene Pressure Pipe in Nominal Pipe Sizes 3/4 in. to 65 in.
x. F3124: Standard Practice for Data Recording the Procedure Used to Produce Heat Butt Fusion Joints
y. F3183: Standard Practice for Guided Side Bend Evaluation of Polyethylene Pipe Butt Fusion Joint
z. F3190: Standard Practice for Heat Fusion Equipment (HFE) Operator Qualification on Polyethylene (PE) and Polyamide (PA) Pipe and Fittings

3. Plastic Pipe Institute (PPI)
   a. PPI Handbook of Polyethylene Pipe, most recent edition.
   b. PPI Municipal Advisory Board (MAB) Generic Electrofusion Procedure for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe
   c. PPI Material Handling Guide for HDPE Pipe and Fittings
   d. PPI TR-33 Generic Butt Fusion Joining Procedure for Polyethylene Gas Pipe
   e. PPI TR-34 Disinfection of Newly Constructed Polyethylene Water Mains
   f. PPI TR-38 Bolt Torque for Polyethylene Flanged Joints
   g. PPI TR-41 Generic Saddle Fusion Joining Procedure for Polyethylene Gas Piping
   h. PPI TN-42 Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects
   i. PPI TR-46 Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe

4. American Water Works Association (AWWA):
   a. C651: Standard for Disinfecting Water Mains
   b. C901: Polyethylene (PE) Pressure Pipe and Tubing
   c. C906: Large Polyethylene (PE) Pressure Pipe and Fittings
   d. M55: PE Pipe – Design and Installation

B. Reference Documents:
   i. “Geotechnical Engineering Report – XXX”

1.3 SUBMITTALS

A. Submittals shall be made in accordance with Uniform General and Supplementary Conditions.

B. All submittals shall be approved by the Engineer prior to delivery.

1.4 ACTION SUBMITTALS/INFORMATIONAL SUBMITTALS

A. Product Data:
   i. May be provided by the Owner for projects with Owner Supplied Pipe:
      a. Certification with each delivery that pipe meets or exceeds the requirements of this Specification, applicable Standards (AWWA, ASTM, ISO, Plastic Pipe Institute, and applicable others). This shall be in the form of a written document from the manufacturer attesting to the manufacturing process meeting the standards.
b. Certified copies of test reports with each delivery, stating compliance with ASTM F714 and ASTM D3350 as appropriate

2. The qualifications of the certified fusion technician in accordance with Paragraph 1.6 D.

3. Provide a copy of the certified fusion technician's training records and experience with the proposed pipe size.

4. Pipe manufacturer's joint assembly procedure and records of each joint butt-fusion, as specified in Paragraph 1.6 D.

5. Prior to construction, provide the following information for all proposed pipe sizes, fittings, and wall thicknesses:
   a. Acceptable range for heater surface temperature
   b. Minimum melt bead size
   c. Maximum Heater Plate Removal Times
   d. Minimum Heat Soak Time & Cooling Time

6. Prior to construction, provide written and photographic documentation of bend back testing of fused joints in accordance with ASTM F2620, Appendix X4.4-X4 for each certified fusion technician.

7. Provide a statement in writing from the manufacturer that it is listed with the Plastic Pipe Institute as a qualified extruder for the polyethylene resin being used to manufacture the pipe for this project.

8. Provide a certificate of compliance from the manufacturer that the pipe, fittings and other products or materials furnished for the project have been inspected at the plant and comply with all applicable provisions of these Specifications. The Contractor shall submit these certificates to the Owner and Engineer prior to installation of the pipe materials.

B. Shop Drawings:

1. May be provided by the Owner for projects with Owner Supplied Pipe:
   a. Pipe dimensions
   b. Joints
   c. Wall Thickness
   d. Pipe Stiffness

2. Pipe Specials

3. Fittings
   a. Details of fittings and specials such as elbows, wyes, tees, outlets, connections, test bulkheads, bosses nozzles or other specials where shown on the Construction Drawings, which indicate amount and position
of reinforcement. All fittings and specials shall be properly reinforced to withstand the internal pressure both circumferential and longitudinal, and the external loading conditions as indicated in the Contract Documents. Shop Drawings shall clearly detail special castings indicating all pertinent dimensions.

4. Outlets
5. Connections to other pipe materials
6. Other details for each size of pipe indicated
7. Placement of pipe within layout area, showing location of temporary pipe support(s) and location and size of bending radius for all curves along the alignment

C. Testing procedures

1. The Contractor shall submit testing procedures for pre-installation and post-installation pressure and bacteriological tests.

2. The Contractor shall submit testing procedures for post-installation mandrel test for gravity pipelines.

1.5 CLOSEOUT SUBMITTALS

A. The Contractor shall submit testing procedures for pre-installation and post-installation pressure and bacteriological tests.

B. The Contractor shall submit pressure test records for both the pre-installation and post-installation tests to the Engineer within 48 hours of completion of the tests.

C. Results of post-installation mandrel test to confirm deflections of installed pipe are less than maximum allowable deflection.

D. The Contractor shall submit post-installation CCTV inspection and results of mandrel testing of gravity pipelines.

1.6 QUALITY ASSURANCE

A. The Contractor shall furnish all labor necessary to assist the Owner in inspecting pipe upon delivery. Contractor shall remove rejected pipe immediately.

B. The Contractor shall perform all tests in accordance with ASTM F2164 and the requirements of this Section. The acceptance or rejection of the pipe shall be based on the test results and conformance with these Specifications. The Contractor shall submit test results and records to the Engineer within 48 hours of completion of tests.
C. Butt-fusion of pipe sections shall be performed by a certified fusion technician. Manufacturer’s recommended practices shall be followed.

D. The Fusion Technician’s certification shall be current and within two years of the start of the project. The Fusion Technician shall also have a minimum of two years of experience and 10,000 linear feet of HDPE pipe fusion of similar size (within one pipe diameter) of the proposed pipe.

E. The Contractor shall provide records of butt-fusion of each joint including data recorded by a McElroy Datalogger or equal. Recorded data shall include the following information: date and time, joint number, operator identification, machine type, pipe size and DR, interfacial pressure during fusion and cooling, gauge pressure during fusion and cooling, and fusion temperature.

1.7 DELIVERY, STORAGE, AND HANDLING

A. The manufacturer shall package product in a manner designed to deliver the pipe and fittings to the project neatly, intact and without physical damage. During transportation each pipe shall rest on suitable pads, strips skids, or blocks securely wedged or tied in place. The transportation carriers shall use appropriate methods and intermittent checks to ensure the pipe is properly supported, stacked and restrained during transportation such that the pipe is not nicked, gouged, or physically damaged.

B. Handle the pipe in accordance with the PPI Handbook of Polyethylene Pipe (2nd Edition), Chapter 2. All pipe and accessories shall be loaded and unloaded by lifting with hoists or by skidding in order to avoid shock or damage. Under no circumstances shall materials be dropped. Pipe handled on skidways shall not be rolled or skidded against pipe on the ground. Slings, hooks or pipe tongs shall be padded and used in such a manner as to prevent damage to the exterior surface or interior of the pipe. All pipe and fittings shall be subjected to visual inspection at time of delivery and before they are lowered into the trench to be laid. Joints or fittings that do not conform to these specifications will be rejected and must be removed immediately by the Contractor.

C. Materials, if stored, shall be kept safe from damage. The contractor shall be responsible for all security, damage, and loss of pipe. The interior of the pipe as well as all sealing surfaces of mating components (i.e. flange faces) shall be kept free from dirt or foreign matter at all times.

D. Pipe shall not be stacked higher than the limits recommended by the manufacturer. The bottom tiers shall be kept off the ground on timbers, rails, or concrete. Pipe shall not be stored close to heat source.
E. Where possible, the pipe shall be raised and supported at a suitable distance from the open end such that the open end will be below the level of the pipe at the point of support.

F. The Contractor shall provide and use a temporary pipe storage area as needed to protect the pipe prior to installation.

G. Store all pipe materials in accordance with pipe manufacturer's recommendations until installation.
   1. Keep pipe at ambient outdoor temperature.
   2. Avoid covering practices that will cause a temperature build-up.

H. Handle all pipe material in accordance with pipe manufacturer's recommendations. Handle all pipe material carefully to avoid any damage. Gouges, cuts or scratches that are deeper than 10% of the pipe wall thickness shall be cause for rejection of the damaged pipe section.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Design Criteria
   1. General
      a. Pipe sizes 3” and larger shall have a manufacturing standard of ASTM F 714, while pipe smaller than 3” shall be manufactured to the dimensional requirements listed in ASTM D 3035.
      b. Potable water pipelines shall meet AWWA C901 (1/2” to 3”) or AWWA C906 (4” to 63”) and shall be listed as meeting NSF-61.
      c. Manufacturer shall be an ISO 9001 certified manufacturer. The pipe and fitting manufacturer shall have an ongoing Quality Control program for incoming and outgoing materials, and shall assure that the pipe will meet the material requirements of this specification. HDPE resins for manufacturing of pipe shall be checked for density, melt flow rate, and contamination. The facility shall have the necessary testing equipment to verify that pipe meets the AWWA and NSF standards. Pipe shall be checked for outside diameter, wall thickness, length, and surface finish on the inside and outside.
      d. IPS/DIPS diameter as indicated on the plans.
   2. Installation Type
      a. Open Cut
         1) Dimension Ratio (DR): Minimum thickness of DR 17 unless specified otherwise on the plans
      b. Other than Open Cut with Casing
1) Dimension Ration (DR): Minimum thickness of DR 17 for trenchless installations unless specified otherwise on the plans

c. Compression Fit Lining
   1) The pipe shall be installed using compression fit techniques, and open cut pit/tie-in locations, at the locations shown on the Drawings, and as specified in Compression Fit HDPE Pipe Lining specification provided by Owner and/or Engineer.
   2) The pipe shall be installed Dimension Ratio (DR): Minimum thickness of DR 21 for trenchless rehabilitation installations unless specified otherwise on the plans.

d. Horizontal Directional Drill (HDD)
   1) The pipe shall be installed using horizontal directional drilling (HDD) techniques, and open cut tie-in locations, at the locations shown on the Drawings, and as specified in Horizontal Directional Drilling (HDD) specification provided by Owner and/or Engineer.
   2) Each reach of pipe to be installed by HDD methods shall be fully fabricated and tested prior to and after installation, using the procedures described in this Section and referenced Sections and standards.
   3) The HDPE pipe shall be designed to withstand all anticipated service and installation loads.
   4) Dimension Ratio (DR): Minimum thickness of DR 11 for HDD installations unless specified otherwise on the plans

B. Pipe
   1. Pipe and fittings made of high molecular weight, high-density polyethylene pipe (HDPE).
   2. The material shall be listed by the Plastic Pipe Institute (PPI) with a designation of PE 4710 meeting ASTM D3350 minimum cell classification of 445474C. The pipe shall have a HDB value of 1600 psi at 73°F.
   3. For applications where water temperatures are expected to exceed 100°F, pipe and fittings shall meet ASTM D3350 minimum cell classification 445574C. The pipe and fittings shall have an HDB value of 800 psi at 180°F. Pipe shall be Polyethylene Raised Temperature Pipe (PE-RT) and Fittings meeting ASTM F2769.
   4. Pipe and fittings shall contain no recycled compounds except that generated in the manufacturer’s own plant from resin of the same specifications.
   5. Markings and Color
      a. Pipe marked in accordance with ASTM F714 and AWWA C906, including DR and Pressure Rating (PR)
      b. Color
1) Pipe shall be black with three (3) or more longitudinal color strips co-extruded into the pipe.
   a) Water Stripe Color: Blue
   b) Sewer Stripe Color: Green
   c) Reclaim Stripe Color: Purple

6. The pipe shall be homogeneous throughout and free of cracks, holes, foreign inclusions or other injurious defects. Pipe shall be uniform in density and other physical properties.

7. Any pipe not meeting these criteria shall be rejected, unless granted an exception by the Owner.

8. HDPE pipe shall be delivered in 40-foot lengths or longer, but no longer than can be transported over highways, surface streets, and access roads to the site.

9. All thermal system pipe shall be pre-insulated or insulated with mineral powder insulation in accordance with the Underground Piping Systems Design Standard. All pre-insulated pipe shall have seal joints.

C. Fittings

1. General
   a. Fittings shall meet the requirements of AWWA C901 or C906.
   b. Pressure rating shall have a minimum pressure rating equal to or greater than the pipe to which they are joined. Unless otherwise specified on the plans or by the Owner.
   c. Material and Design requirements as specified in previous sections.

2. Butt Fusion Fittings
   a. Molded fittings shall comply with the requirements of ASTM D3261.
   b. Fabricated bends, tees, and caps meet the requirement of ASTM F2206.
      1) Fittings marked per ASTM F2206 section 10 including the nominal size and fitting SDR, which will meet or exceed the pipe DR identified for the project. Fabricated fittings shall be manufactured using a McElroy DataLogger to record fusion pressure and temperature, and shall be stamped with unique joint number that corresponds to the joint report. A graphic representation of the temperature and pressure data for all fusion joints made producing fittings shall be maintained for a minimum of 5 years as part of the quality control and will be available upon request of owner. Test results to validate ASTM F 2206 section 7.3 and 9 shall be provided to owner or owner’s representative upon request.


4. Electrofusion Fittings
a. Shall be used at 45° bends, 90° bends, and where specified on the plans or with prior Owner or Engineer approval.
c. All electrofusion fittings shall have AWWA approval.

5. Mechanical Fittings
a. Shall only be used where specified on the plans or with prior Owner or Engineer approval.
b. Designed and compatible with HDPE Pipe.
c. Couplings to Other Pipe Materials
   1) Couplings shall be restrained with a double restraining gland and stiffener manufactured for use with HDPE pipe.
   2) Connections to PVC may also be made with an HDPE to PVC transition fitting.
d. Saddles
   1) Wide strap for distribution of clamping loads.
   2) No U-bolts
e. Pipe Stiffeners
   1) Interior pipe stiffeners required for all mechanical joint connections.
   2) Design
      a) Support pipe end and control necking
      b) Wedge style
      c) Approved by HDPE manufacturer and selected based on the specified pipe size and DR
   3) Material
      a) 304 or 316 stainless steel

D. Joints
1. Butt-fusion
   a. Butt-fusion joints shall be used for all pipe installed. Friction or pressure couplings are NOT ACCEPTABLE. HDPE flange adapters with back-up flanges may be used at transitions to different pipe materials or appurtenances, subject to Engineer approval of Contractor submittals.
   b. Butt-Fusion Joints: Butt fusion techniques shall meet all requirements of ASTM D 2620 and D3261, and requirements of this Section

2. Bolted Connections
   a. General
      1) Made to ASTM D 3261 or if machined, must meet the requirements of ASTM F 2206.
      2) Flanges and MJ Adapters shall be fused onto the pipe.
      3) Minimum pressure rating equal to or greater than the pipe unless otherwise specified on the plans.
b. Flanged Adapters
   1) Meet the dimensional and material requirements of ASTM F 2880.
   2) Metallic Back-up Rings
      a) Ductile iron with epoxy coating
      b) Van-Stone style lap joint flanges
      c) Radius on the inside diameter of the bore so as to be compatible with HDPE Flanges.
      d) Bolt Pattern that will mate with:
         (1) AWWA C207 Class D (or B or E),
         (2) ASME/ANSI B 16.5 Class 150,
         (3) ASME/ANSI B 16.1 Class 125, or
         (4) ASME/ANSI B16.47 Series A.

   c. Mechanical Joint Adapters
      1) Shall only be used where specified on the plans or with prior Owner or Engineer approval.
      2) Consists of:
         a) Molded or fabricated HDPE mechanical joint transition fitting
         b) Gasket
         c) Mechanical joint back-up drive ring
         d) Bolts in accordance with Bolts, Nuts, and Gaskets specification provided by Engineer.

E. Restraint Systems
   1. Acceptable supplemental restraint systems include wall anchors with concrete encasement or buried poly anchors.

F. Location Equipment
   1. Tracer Wires
      a. Open Cut Install
         1) Wire
            a) High-strength, copper clad steel tracer wire including 45 mil HDPE jacket with a minimum average break load of 1,150 lbs.
            b) Color: Blue for all water and green for sewer.
            c) Gauge: 12 AWG, 10 AWG, or 8 AWG depending upon installation procedures
         2) Splices made only per the manufacturer’s recommended method.
      b. HDD and Boring Install
         1) Three Soloshot Xtreme tracer wires, each of the same length as the HDPE pipe string, shall be provided and attached to the pulling head at 120° separation, and shall be installed with the HDPE pipe.

   2. Buried Markers (Detectable Warning Tape)
      a. Provide detectable warning tape as follows:
1) 5.0 mil overall thickness
2) Width – 3 inch minimum
3) Weight – 27.5 pounds per inch per 1,000 square feet
4) Triple Layer with:
   a) Minimum thickness 0.35 mils solid aluminum foil encased in a protective inert plastic jacket
      (1) 100 percent virgin low density polyethylene
      (2) Impervious to all known alkalis, acids, chemical reagents and solvents within soil
      (3) Aluminum foil visible to both sides
5) Locatable by conductive and inductive methods
6) Printing encased to avoid ink rub-off
7) Color and Legends
   a) All water lines
      (1) Color – Blue (in accordance with APWA Uniform Color Code)
      (2) Legend
         (a) Caution Potable Water Line Below (repeated every 24 inches)
         (b) Caution Chilled Water Line Below (repeated every 24 inches)
         (c) Caution Heating Hot Water Line Below (repeated every 24 inches)
   b) Sewer lines
      (1) Color – Green
      (2) Legend
         (a) Caution Sanitary Sewer Line Below (repeated every 24 inches)
         (b) Caution Storm Sewer Line Below (repeated every 24 inches)

G. Fusion Equipment

1. All Fusion Equipment, whether new or used, rented or owned, shall comply with the requirements of ISO 12176-1 “Equipment for Fusion Jointing Polyethylene Systems”.

2. If the contractor owns butt fusion equipment, the equipment must be serviced within 3 months prior to use for this project. The machine must be environmentally friendly and in satisfactory working order. The hydraulic system must be leak free. The pressure gage and thermometer must be checked for accuracy. The fusion equipment must be serviced by a McElroy
Authorized Service and Repair Center with at least one McElroy Certified Master Mechanic on staff within 3 months from the first fusion on the project.

3. The pipe butt fusion machine shall be a self-contained hydraulic fusion machine capable of butt fusing HDPE pipe. The carriage must be removable from the chassis for in-ditch use. The machine must be compatible with an electronic data recording device. Accessories will include all butt fusion inserts for the specified range of pipe sizes, a pyrometer kit for checking the surface temperature of the heater, extension cord (25’ minimum), and hydraulic extension hoses (minimum of four). The butt fusion machine will be McElroy, or approved equivalent.

4. Rental Fusion Equipment must be maintained by a McElroy Authorized Service and Repair Center with at least one McElroy Certified Master Mechanic on staff. When requested by owner or his authority, an inspection report detailing the components inspected within 3 months prior to arrival at jobsite will be provided.

5. The employer of the fusion machine operator is responsible for the fusion joint quality of the fusion weld made by that individual. The employer is responsible for documenting all qualification and training records of that individual.

6. All HDPE fusion equipment operators shall be qualified to the procedure used to perform pipe joining. Fusion equipment operators shall have current, formal training on all fusion equipment employed on the project. Training received more than two years prior to operation with no evidence of activity within the past 6 months shall not be considered current.

7. Fusion equipment must be compatible with an electronic data recording device.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Pipe Inspection

1. All pipe and fittings shall be subjected to visual inspection at time of delivery and before they are installed or lowered into the trench to be laid. Defective, damaged, or unsound pipe will be rejected. Cuts, punctures, or gouges that penetrate or reduce the wall thickness by 10% or more are not acceptable and must be removed and discarded. Joints or fittings that do not conform to these specifications will be rejected and must be removed immediately by the Contractor.

B. Examine the pipe layout area for evidence of rocks, debris, or other objects that could damage the pipe during layout, fabrication, or installation. Remove all such object and ensure layout area is compatible with Contractor’s operations.
C. Examine each pipe and fitting, the fabricated pipeline, and the layout area prior to pull/installation to ensure:

1. No obstruction existing along the layout area that might interfere with installation
2. No defects exist in the pipe string, butt fusion welds, pulling head, swivels, break-away couplings, etc.

D. Inspect each pipe and fitting prior to fusion of the joints. Remove defective pipe and fittings from the site.

E. Inspect the pipe string prior to installation for any defects. Repair any defects prior to installation according to manufacturer’s recommendations and in accordance with these Specifications.

3.2 PREPARATION

A. The length of fabricated and installed pipeline shall be sufficient to allow for expansion, contraction, and connections to adjacent pipe sections. The coefficient of linear expansion of HDPE pipe to be used for this calculation is 1.2 x 10^-4 in./in./degree F.

B. The Contractor shall provide supports and rollers along the pipe layout area to support the pipe during installation and to protect the pipe from damage by stones, debris, etc., on the ground. The pipe may not be dragged across the ground to be moved into place.

C. The pipe layout and fabrication area shall be within the areas specified on the Drawings, or otherwise approved in writing by the Owner. The pipe shall not obstruct traffic.

D. The Contractor shall provide all necessary protective padding materials and skids to protect the pipe during storage, fabrication, and installation.

3.3 INSTALLATION

A. General

1. HDPE pipe and fittings shall be cut, joined, and installed in accordance with the manufacturer’s recommendations. Joining, laying, and pulling of polyethylene pipe shall be accomplished by personnel experienced in working with polyethylene pipe systems.

B. Direct Burial

1. Buried HDPE pipe and fittings shall be installed in accordance with ASTM D2321 or ASTM D2274 for pressure systems and AWWA Manual of Practice M55 Chapter 8.
2. Buried HDPE pipe shall be allowed to cool and contract prior to making a connection to an anchored joint, flange, or fitting that requires protection against excessive pull-out forces.

3. Pipe embedment – Embedment material should be Class I, Class II, or Class III materials as defined by ASTM D2321 Section 6. The use of Class IV and Class V materials is not allowed, unless approved by the Engineer or Owner.

4. Bedding: Pipe bedding shall be in conformance with ASTM D2321 Section 8. Compaction rates should be as specified in ASTM D2321. Deviations shall be approved by the Engineer.

5. Haunching and backfill shall be as specified in ASTM D2321 Section 9 with Class I, II, or III materials. Compaction shall be in excess of 85% Proctor.

C. Trenchless Installation Methods

1. Installation of HDPE pipe by horizontal direction drilling shall follow the guidelines outlined in ASTM F1962 or PPI TR-46.

2. Installation of HDPE pipe by slip lining shall follow the guidelines outlined in ASTM F585.

3. Installation of HDPE pipe by pipe bursting shall follow the guidelines of the International Pipe Bursting Association (IPBA).

D. Joints: All HDPE pipe joints shall be completed in accordance with manufacturer’s recommendations.

1. Thermal Butt-Fusion: The Contractor shall join all sections of HDPE pipe together, using thermal butt-fusion. The Contractor shall obtain acceptable fusion parameters from the pipe manufacturer, with regard to fusion temperature, interface pressure, and cooling time. The Contractor shall follow the manufacturer’s recommendations with regard to the acceptable fusion parameters, and shall use proper equipment for the fusion process. The Contractor shall employ only trained, experienced personnel trained by the fusion equipment manufacturer or pipe manufacturer to conduct the fusion process.
   a. Fusion procedures in accordance with ASTM F 2620 or PPI TR-33.
   b. Joints made by a qualified technician per PPI TN-42.
   c. Fusion Data Records
      1) For 6” and larger pipe sizes, McElroy DataLogger or equivalent fusion data recorder shall be used to record all fusion welds on hydraulically operated fusion machines. The device shall be capable of meeting the requirements of ASTM F 3124, “Standard Practice for Data Recording the Procedure used to Produce Heat Butt Fusion Joints in Plastic Underground Piping Installations Appendix B - High Density Polyethylene (HDPE) Pipe and Fittings
Page 15 of 21
Piping Systems or Fittings”. The device, or combination of devices, shall record the following variables of each fused joint:

a) Heater surface temperature immediately before inserting the heater plate. Alternatively, the heater plate may be measured with a pyrometer and entered into the weld record.

b) Ambient air temperature

c) Gauge pressure during the initial heat cycle
d) Gauge pressure and elapsed time during the heat-soak cycle
e) Heater removal (dwell) time
f) Gauge pressure and elapsed time during the fusing/cool cycle
g) Drag pressure
h) Pipe diameter and wall thickness
i) Type of HDPE material (Specification and Classification) and manufacturer

j) Fusion Machine Identification
k) Geo-reference for location of fused joint. Updated geo-reference for installed location if different
l) Operators Name or Initials
m) Date and time of fusion

d. Remove exterior beads

e. Records showing the device is up to date on all required calibration should be available for presentation when requested.

2. Flanged Joints: The Contractor shall provide a manufacturer approved gasket and assemble and torqued according to PPI TN-38, “Bolt Torque for Polyethylene Flanged Joints.”

3. Electrofusion: Electrofusion joining when allowed shall be done in accordance with the manufacturers recommended procedure. Other sources of electrofusion joining information are ASTM F 1290, PPI TN 34, and PPI Municipal Advisory Board (MAB) Generic Electrofusion Procedure for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe. The process of electrofusion requires an electric source, commonly called an electrofusion processor that has wire leads and a method to read electronically (by laser) or otherwise input the barcode of the fitting. The electrofusion processor must be capable of reading and storing the input parameters and the fusion results for later download to a record file. Qualification of the fusion technician shall be demonstrated by evidence of electrofusion training within the past year on the equipment to be utilized for this project.

a. The Contractor shall record and provide GPS data of each electrofusion installation.

E. Restraint Systems
1. For CHW and HHW pipe systems, supplemental restraint shall be installed at all bends equal to or greater than 45°. Supplemental restraint systems shall be concrete encased wall anchors or buried poly anchors within 5 feet of each leg of the bend.

F. Night Caps

1. The open ends of all sections of joined and/or installed pipe (not in service) shall be plugged to prevent animals or foreign material from entering the pipe line or pipe section. The practice of stuffing cloth or paper in the open ends of the pipe will not be permitted. Waterproof nightcaps of approved design may be used but they shall be so constructed that they will prevent the entrance of any type of natural precipitation into the pipe and will be secured to the pipe in such a manner that the wind cannot blow them loose.

G. Tracer Wire

1. Wire shall be continuous and brought up in the valve boxes or appurtenances along the main.

H. Buried Markers (Detectable Warning Tape)

1. Install in accordance with manufacturer’s recommendations below natural ground surface and directly above the utility for which it is marking.
   a. Allow 18 inches minimum between utility and marker.
   b. Bury to a depth of 3 feet or as close to the grade as is practical for optimum protection and detectability.

3.4 FIELD [OR] SITE QUALITY CONTROL

A. The Contractor shall furnish and install all temporary testing plugs or caps, pressure pumps, pipe connections, meters, gauges, equipment and labor.

B. The Contractor shall notify Owner at least 48 hours prior to testing.

C. All pumps, valves, temporary connections, meters, gauges and other measuring devices shall be furnished, installed and operated by the Contractor and all such equipment and devices and their installation shall be approved by the Owner. The Contractor shall restrain pipe, components, and test equipment as required to ensure testing can be accomplished in a safe manner, including protection of personnel, equipment, and public in the event of a failure during testing.

D. The pressure gauges or data recorders should be calibrated and sufficiently sized to provide mid-range data (pressure tested will not be below 10% or greater than 90% of gauge capacity) that result in easy reading and interpretation. Gauges shall be accurate to within 2% of full scale with increments no greater than 5 psi.

E. Fusion Examination and Testing:
1. Examinations
   a. Visual: For pipe sections, examine the full exterior circumference for bead uniformity before cutting. After cutting the pipe section, review the interior bead. All beads should have visually acceptable bead formation as shown in Fig 4 and Appendix X2 of ASTM F 2620. In addition, the following characteristics are expected:
      1) There shall be no evidence of cracks or incomplete fusing
      2) There shall be no evidence of captured objects (e.g., pipe shavings, facer ribbons) between bonded surfaces.
      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 the fused joint shall remain above the base material surface
      5) Fused joints shall not display visible angular misalignment, and outside diameter mismatch shall be less than 10% of the nominal wall thickness
      6) Fusion data record review that meet criteria of section 3.3(B)(1)(c) can be used as additional verification of visual indicators.
   b. Fusion Data Record Review
      The fusion data record for each fused joint shall be compared to the approved fusion procedure. The reviewer shall verify the following:
      1) That all data required by section 3.3(D)(1)(c) was recorded
      2) Interfacial pressure was within the acceptable range
      3) Heater surface temperature was within the acceptable range
      4) Butt fusion pressure applied during the fusing/cool cycle was correctly calculated to include drag pressure, fell within the acceptable range for the applicable size and agrees with the recorded hydraulic fusing pressure.
      5) Butt fusing pressure was reduced to a value less than or equal to drag pressure at the beginning of the heat soak cycle.
      6) Fusing machine was opened at the end of the heat soak cycle, the heater was removed, and the end were brought together at the fusion pressure with the acceptable time range
      7) Cooling time at butt fusing pressure met the minimum time specified
   c. If the recorded data in section 3.4(E)(1)(b) is outside the limits of the acceptable range, the joint is unacceptable.
   d. Frequency. Records for test fusion joints should be reviewed immediately after the joint is completed. Fusion joints for jobsite fusions should be reviewed daily or before being covered with backfill.

2. Mechanical Tests
a. Contractor shall mechanically test the first fusion of each operator and each machine used on the project. Installation shall not continue until a fusion test has passed the test. Additional mechanical tests are not required as long as the fusions are reviewed with the frequency specified in section 3.4(E)(1)(d). Testing of fusion joints with no fusion data record review shall be at a frequency specified by the Owner or Engineer.

b. The fusion shall be allowed to cool completely, then fusion test straps shall be cut out.

c. All samples shall be labeled with operator information. Testing must be done at 73° F plus or minus 5°. The test temperature and sample size are critical to testing. Testing performed at cold or elevated temperatures may not give similar results to tests performed at ambient temperatures.

d. Each pipe sample weld shall be subjected to testing at two locations 180° apart from each other in the joint weld. All specimens shall be tested by one of the following methods:

   1) Reverse Bend Test are allowed for pipe sizes 4” IPS or smaller. The specimens shall be prepared and tested in accordance with ASTM F 2620, Appendix X4.

   2) Guided Side Bend Test are allowed for all wall thicknesses of 1” or greater. The specimens shall be removed and tested in accordance with ASTM F 3183.

   3) Hydrostatic Burst Test is allowed for pipe sizes 2”-24”. The specimen length should measure 6 times pipe diameter with the butt fusion joint in the center of the specimen. The specimen should be tested in a tank filled with water, and testing conditions monitored and recorded with computerized equipment. The specimen will be tested at 4 times pipe rated pressure for 5 minutes with no failure of joint allowed.

e. Results of any mechanical test should be documented. Information on the weld and operator should be transferred from the sample to the testing record.

F. Testing and Leakage

1. Gravity pipelines – The Contractor shall perform a low pressure air test for gravity flow pipelines to the requirements of ASTM F1473. The Contractor shall also provide a post construction CCTV inspection of the pipeline and a mandrel test using a mandrel with an outside diameter that is 95% of the pipeline inside diameter.

2. Pressure pipelines – Pressure testing shall be conducted in accordance with requirements and recommendations of ASTM F2164 (Field Leak Testing of Polyethylene Pressure Piping Systems Using Hydrostatic Pressure), AWWA Manual of Practice M55 Chapter 9, and PPI Handbook of Polyethylene Pipe
Chapter 2 (2nd Edition). Pneumatic (compressed air) leakage testing of HDPE pressure piping is prohibited for safety reasons.

a. The section of pipe to be tested shall be filled with potable water approved by the Owner/Engineer. While the system is being filled with water, air shall be carefully and completely exhausted. If permanent air vents are not located at all high points, the Contractor shall install fittings and valves at such points so the air can be expelled as the pipe system is slowly filled with water.

b. The Contractor shall not perform hydrostatic testing against existing valves, unless approved by the Owner/Engineer.

c. The test procedure for HDPE pipe consists of two steps: 1) the initial phase or expansion phase and 2) the test phase. During the initial/expansion phase, sufficient make-up water shall be added hourly for 3 hours to return to the test pressure. During the test phase, the expansion phase pressure is reduced by 10 psi to test phase pressure and monitored for at least one hour (3 hours maximum).

d. Under no circumstances shall the total time under test exceed eight (8) hours. If the test is not completed due to leakage, equipment failure or any other reason, depressurize the test section and permit the system to “relax” for eight (8) hours prior to the next testing sequence.

e. The test pressure should be related to the lowest point in elevation along the test section’s vertical pipeline profile.

f. All pressure and leakage testing shall be done in the presence of a representative of the Owner and Engineer.

g. The test pressure shall be 1.5 times the operating pressure at the lowest point in the system. In accordance with section 9.8 of ASTM F 2164, the pipe shall pass if the final pressure is within 5% of the test phase pressure for the testing period (3 hours maximum). If the test section fails this test, the Contractor shall repair or replace all defective materials and/or workmanship at no additional cost to the Owner.

G. Flushing, Cleaning and Disinfection

1. All mains shall be cleaned and flushed to remove all dirt, sand, debris and other foreign matter. The Contractor shall be responsible for developing a flushing plan to be submitted to the Engineer for approval prior to flushing.

2. Disinfection
a. Cleaning and disinfecting of potable water systems shall be in accordance with AWWA C651 and AWWA Manual of Practice M 9 Chapter 9, and PPI Handbook of Polyethylene Pipe Chapter 2 (2nd Edition).

b. The disinfection chemicals should be limited to less than 12% active chlorine. The duration of the disinfection should not exceed 24 hours.

c. Upon completion, the system should be thoroughly flushed with fresh water, and sampled to verify the disinfectant chlorine level has been reduced to potable drinking water concentrations in all service water tubing and branch lateral pipes.

H. Testing Outside the Trench (Trenchless Installations)

1. Pre-Installation Joint Integrity Test
   a. Perform hydrostatic pre-testing of the pipe in the presence of the Owner before installation.
   b. Test pressures and air temperatures shall be monitored with appropriate measurement equipment that has been calibrated and inspected prior to the test.
   c. The pre-installation test pressure shall be at 100% of the rated pipe pressure.
   d. The Contractor shall repair any defects discovered during this test, and repeat the test until the test pressure can be maintained.
   e. The area shall be secured and fenced off prior to testing.

2. Final Acceptance Post-Installation Test
   a. The Contractor shall conduct a final pressure test of each installed pipeline in accordance with the Pressure Testing section of this Section.

3. The Contractor shall conduct additional tests and repairs until pipe section passes pressure and leakage tests at no additional cost to the Owner, and without schedule extension.

I. As-Built Documentation

1. Contractor shall submit certified dimensional as-built drawings/profile of all installed pipe, specials and fittings for Owner and Engineer approval.
APPENDIX C
Ductile Iron Pipe
Appendix C
Ductile Iron Pipe and Fittings

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish labor, materials, equipment, and incidentals necessary to install ductile-iron pressure pipe for heating hot water (HHW) systems, including connections and appurtenances as required for the proper installation and function of the system, as shown on the drawings and described herein.

B. Polyethylene encasement for ductile iron pipe is detailed in this Section.

1.2 REFERENCES

A. Reference Standards
   1. Reference standards cited in this specification refer to the current reference standard published at the time of the contract.
   2. American National Standards Institute (ANSI)/American Water Works Association (AWWA)
      b. ANSI/AWWA C105/A21.5 - American National Standard for Polyethylene Encasement.
      e. ANSI/AWWA C151/A21.51 - American National Standard for the Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.
      f. ANSI/AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
      g. AWWA M-41 - Ductile-Iron Pipe and Fittings.

B. Reference Documents
   1. “Geotechnical Engineering Report – XXX”

1.3 SUBMITTALS

A. Submittals shall be made in accordance with Uniform General and Supplementary Conditions.

B. All submittals shall be approved by the Engineer prior to delivery and/or fabrication for specials.
1.4 ACTION SUBMITTALS/INFORMATIONAL SUBMITTALS

A. Product Data
   1. Pipe data including a complete description of the pipe being offered.
   2. Polyethylene encasement
   3. Submittal for painting exterior pipe to include recommendation for preparation, application and storage.

B. Certificates
   1. Prior to delivery of the pipe to the project site, the manufacturer shall furnish an affidavit certifying that all pipe, fittings, and specials, and other products and materials furnished, comply with this specification.
   2. The manufacturer shall submit certified reports of all testing.

1.5 QUALITY ASSURANCE

A. Manufacturer: Finished pipe shall be the product of one (1) manufacturer. Pipe manufacturing operations (pipe, fittings, lining, coating) shall be performed at one (1) location.
B. The Contractor shall perform hydrostatic testing in accordance with AWWA C600 and shall submit test results and records to the Engineer within 48 hours of completion of tests.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Storage shall be in accordance with ANSI/AWWA C600 and AWWA M41.

PART 2 - PRODUCTS

2.1 DUCTILE IRON PIPE

A. Manufacturers
   1. The following manufacturers are acceptable
      a. American Cast Iron Pipe Company
      b. McWane Ductile
      c. U.S. Pipe
      d. Or Approved Equal

B. Regulatory Requirements
   1. Pipe shall be in accordance with AWWA C111, AWWA C150, and AWWA C151.
   2. ALL MATERIALS SHALL BE OF DOMESTIC MANUFACTURE.

C. Performance/Design Criteria
1. Pipe joint shall be as bell and spigot, flanged and plain end as shown on the drawings.
2. Pipe shall be Pressure Class 150.
3. Ductile iron pipe shall have nominal lay lengths of 20 feet. Dimensions and tolerances of each nominal pipe size shall be in accordance with ANSI/AWWA C151/A21.
4. Pipe markings shall meet the minimum requirements of ANSI/AWWA C151/A21, latest revision. Minimum pipe markings shall be as follows:
   a. “DI” or “DUCTILE” shall be cast or metal stamped on each pipe
   b. Weight, pressure class, and nominal thickness of each pipe
   c. Year and country pipe was cast
   d. Manufacturer’s mark
5. Joints
   b. All rubber joint gaskets utilized on ductile-iron pipe shall be in conformance with ANSI/AWWA C111/A21.11, latest revision.
   c. Gaskets shall be EPDM with a 220°F temperature rating.
6. Joint Restraints shall be as follows:

<table>
<thead>
<tr>
<th>DIP Diameters</th>
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<tbody>
<tr>
<td>4” – 12”</td>
<td>16” – 20”</td>
<td>24” – 42”</td>
<td>48” &amp; Larger</td>
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<tr>
<td>VALVES</td>
<td>FITTINGS</td>
<td>VALVES</td>
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<td>MECHANICAL JOINT WITH MEGALUGS</td>
<td>MECHANICAL JOINT WITH MEGALUGS</td>
<td>MJ WITH MEGALUGS OR RESTRAINED PUSH-ON JOINT*</td>
<td>MJ WITH MEGALUGS OR LOK – RING** JOINTS</td>
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<td>PIPE</td>
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<td>RESTRAINED PUSH-ON JOINT*</td>
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*TR-FLEX BY US PIPE, FLEX-RING BY ACIPCO, OR APPROVED EQUAL
**LOK-RING BY ACIPCO, OR APPROVED EQUAL
*FLANGED FOR SLEEVES TO A VAULT OR A BUILDING
NOTE: VICTAULIC AND SHUR-LOK ARE ACCEPTABLE RESTRAINED JOINTS
E. Minimum pressure class shall be as follows:

<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Minimum Pressure Class</th>
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<tbody>
<tr>
<td>6”</td>
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<tr>
<td>8”</td>
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<tr>
<td>12”</td>
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<td>250 psi</td>
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<tr>
<td>30”</td>
<td>150 psi</td>
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F. Mechanical thrust restraint may be done with: Series 1100 Megalugs by EBAA Iron for ductile iron pipe mechanical joints or approved equal.

G. Materials
   1. Iron used in the manufacture of pipe for these specifications shall have:
      a. Minimum tensile strength – 60,000 psi
      b. Minimum yield strength – 42,000 psi
      c. Minimum elongation – 10%

H. Finishes
   1. Finish Materials
      a. Exterior Coating Buried
         1. Asphaltic coating, minimum of 1 mil thickness
      b. Interior Lining
         1. All ductile iron pipe shall have a cement mortar lining applied to the interior.

2.2 DUCTILE IRON FITTINGS

A. Fittings shall be in accordance with the applicable requirements of ANSI/AWWA C110.

B. Compact fittings, AWWA C153, will be allowed for this project.

2.3 POLYETHYLENE ENCASEMENT:

A. All buried ductile iron pipe shall be polyethylene encased in accordance with AWWA C105.

B. Use only virgin polyethylene material.

C. Encasement for buried pipe shall be 4 mil high density cross-laminated (HDCL) polyethylene encasement conforming to AWWA C105/A21.5.
D. Polyethylene film must be marked as follows:
   1. Manufacturer’s name or trademark
   2. Year of manufacturer
   3. ANSI/AWWA C105/A21.5
   4. Minimum film thickness and material type
   5. Applicable range of nominal diameter size(s).
   6. Warning-Corrosion Protection-Repair Any Damage

E. Special Markings/Colors
   1. Label polyethylene encasement with “HHW”;
   2. Provide BLUE polyethylene in accordance with the American Public Works Association Uniform Color Code; or
   3. Attach blue water marker tape to the polyethylene wrap.

F. Minimum Widths:

<table>
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<tr>
<th>Nominal Pipe Diameter (inches)</th>
<th>Min. Width – Flat Tube (inches)</th>
<th>Min. Width – Sheet (inches)</th>
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<tr>
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**PART 3 - EXECUTION**

3.1 GENERAL:

A. Install pipe in accordance with AWWA M41, AWWA C600, and in accordance with the pipe manufacturer’s recommendations.
B. All pipe shall be restrained.

C. Polyethylene encasement shall be installed in accordance with AWWA C105 and AWWA M41, Method A or B. Method C will not be allowed.

D. All exposed pipe shall be painted.

E. Perform hydrostatic test and disinfect piping as specified in AWWA C600.

F. All thermal system pipe shall be pre-insulated or insulated with mineral powder insulation in accordance with the Underground Piping Systems Design Standard. All pre-insulated pipe shall have sealed joints.

3.2 PIPE HANDLING

A. Haul and distribute pipe at the project site.

B. Handle piping with care to avoid damage.
   1. Inspect each joint of pipe and reject or repair any damaged pipe prior to lowering into the trench.
   2. Do not handle the pipe in such a way that will damage the interior lining.
   3. Use only nylon ropes, slings or other lifting devices that will not damage the surface of the pipe for handling the pipe.

C. At the close of each operating day:
   1. Keep the pipe clean and free of debris, dirt, animals and trash – during and after the laying operation.
   2. Effectively seal the open end of the pipe using a gasketed night cap.

3.3 JOINT MAKING

A. Push-on Joints
   1. Install Push-on joints as defined in AWWA/ANSI C111/A21.11.
   2. Wipe clean the gasket seat inside the bell of all extraneous matter.
   3. Place the gasket in the bell in the position prescribed by the manufacturer.
   4. Apply a thin film of non-toxic vegetable soap lubricant to the inside of the gasket and the outside of the spigot prior to entering the spigot into the bell.
   5. When using a field cut plain end piece of pipe, refinish the field cut and scarf to conform to AWWA C600.

B. Joint Deflection
   1. Deflect the pipe only when necessary to avoid obstructions or to meet the lines and grades and shown in the Drawings.
   2. The deflection of each joint must be in accordance with AWWA C600 Table 3.
3. The maximum deflection allowed is 80 percent of that indicated in AWWA C600.
4. The manufacturer’s recommendation may be used with the approval of the Engineer.

C. Connections to Steel Pipe
1. Install dielectric insulating flanges at connections to steel pipe.

3.4 POLYETHYLENE ENCASEMENT INSTALLATION

A. Preparation
1. Remove all lumps of clay, mud, cinders, etc., on pipe surface prior to installation of polyethylene encasement.
   a. Prevent soil or embedment material from becoming trapped between pipe and polyethylene.
2. Fit polyethylene film to contour of pipe to affect a snug, but not tight encasement with minimum space between polyethylene and pipe.
   a. Provide sufficient slack in contouring to prevent stretching polyethylene where it bridges irregular surfaces such as bell-spigot interfaces, bolted joints or fittings and to prevent damage to polyethylene due to backfilling operations.
   b. Secure overlaps and ends with adhesive tape and hold.
3. For installations below water table and/or in areas subject to tidal actions, seal both ends of polyethylene tube with adhesive tape at joint overlap.

B. Tubular Type (Method A)
1. Cut polyethylene tube to length approximately 2 feet longer than pipe section.
2. Slip tube around pipe, centering it to provide 1-foot overlap on each adjacent pipe section and bunching it accordion-fashion lengthwise until it clears pipe ends.
3. Lower pipe into trench and make up pipe joint with preceding section of pipe.
4. Make shallow bell hole at joints to facilitate installation of polyethylene tube.
5. After assembling pipe joint, make overlap of polyethylene tube, pull bunched polyethylene from preceding length of pipe, slip it over end of the new length of pipe and wrap until it overlaps joint at end of preceding length of pipe.
7. Take up slack width at top of pipe to make a snug, but not tight, fit along barrel of pipe, securing fold at quarter points.
8. Repair cuts, tears, punctures or other damage to polyethylene.
9. Proceed with installation of next pipe in same manner.

C. Tubular Type (Method B)
1. Cut polyethylene tube to length approximately 1 foot shorter than pipe section.
2. Slip tube around pipe, centering it to provide 6 inches of bare pipe at each end.
3. Take up slack width at top of pipe to make a snug, but not tight, fit along barrel of pipe, securing fold at quarter points; secure ends.
4. Before making up joint, slip 3-foot length of polyethylene tube over end of proceeding pipe section, bunching it accordion-fashion lengthwise.
5. After completing joint, pull 3-foot length of polyethylene over joint, overlapping polyethylene previously installed on each adjacent section of pipe by at least 1 foot; make each end snug and secure.

D. Sheet Type
1. Cut polyethylene sheet to a length approximately 2 feet longer than pipe section.
2. Center length to provide 1-foot overlap on each adjacent pipe section, bunching it until it clears the pipe ends.
3. Wrap polyethylene around pipe so that it circumferentially overlaps top quadrant of pipe.
4. Secure cut edge of polyethylene sheet at intervals of approximately 3 feet.
5. Lower wrapped pipe into trench and make up pipe joint with preceding section of pipe.
6. Make shallow bell hole at joints to facilitate installation of polyethylene.
7. After completing joint, make overlap and secure ends.
8. Repair cuts, tears, punctures or other damage to polyethylene.
9. Proceed with installation of next section of pipe in same manner.

E. Repairs
1. Repair any cuts, tears, punctures or damage to polyethylene with adhesive tape or with short length of polyethylene sheet or cut open tube, wrapped around fitting to cover damaged area and secured in place.

F. Junctions between Wrapped and Unwrapped Pipe:
1. Where polyethylene-wrapped pipe joins an adjacent pipe that is not wrapped, extend polyethylene wrap to cover adjacent pipe for distance of at least 3 feet.
2. Secure end with circumferential turns of tape.
3. Wrap service lines of dissimilar metals with polyethylene or suitable dielectric tape for minimum clear distance of 3 feet away from Cast or Ductile Iron Pipe.