SECTION 02662

HIGH DENSITY POLYETHYLENE WATER MAIN PIPE

PART 1 GENERAL

1.1 SUMMARY

A. This Section includes the material standards, joining methods, and general installation practice for high density polyethylene pipe used in potable water supply systems. This Section also includes fittings, tapping, hydrostatic testing, disinfection, and connection requirements for the installation of high density polyethylene pipe.

B. Related Requirements
1. Section 02315 – Utility Trenching, Backfill and Compaction
2. Section 02336 – Horizontal Directional Drilling (Water Main)
3. Section 02660 – Water Main Systems
4. Section 02661 – Ductile Iron Water Main Pipe
5. Section 02741 – Pipe Bursting Method for Water Main Replacement

1.2 MEASUREMENT AND PAYMENT

A. Water main, service connections, taps and any other appurtenances will be measured and paid for as described in the related Sections for water main installation.

B. **Concrete Restraining Block .....Each:**
This bid item shall be paid for at the Contract Unit Price per each restraining block, installed and completed. The Work required by this item is described in the Water Main Standard Details includes preparing a vertical wall of undisturbed earth in which to place the restraining block against, installation of flex restraint devices on to the HDPE pipe, and the forming, furnishing, installation, reinforcing steel, and curing of the concrete block to the dimensions shown in the project details, completely encasing the flex restraints. All labor, tools and material necessary to remove the fusion bead and provide for a smooth pipe interior at the joint location, shall be considered as part of the **Concrete Restraining Block** Work.

C. **Interior Pipe Debeading, ___ inch.....Each:**
The Owner shall pay for **Interior Pipe Debeading, ____ inch** of the diameter specified at the contract unit price for each fusion bead that is removed, and shall include all Work to provide a smooth surface on the interior of the pipeline after pipe joining operations are completed. Measurement of **Interior Pipe Debeading ____ inch** will be taken when the interior bead has been removed and the water main has passed all acceptance testing. All labor, tools and material necessary to remove the fusion bead and provide for a smooth pipe interior at the joint location, shall be considered as part of the **Interior Pipe Debeading, ____ inch** Work.

D. The costs for all testing and disinfection required by State and public health officials prior to connection to the existing water supply system will not be paid separately, and are to be included unit price bid for water main as described in Article 1.2.A

1.3 REFERENCES

A. Abbreviations and Acronyms
1. HDPE – High Density Polyethylene
2. ANSI – American National Standards Institute (www.ansi.org)
3. AWWA - American Water Works Association (www.awwa.org)
4. PPI – Plastics Pipe Institute
5. PR – Pressure Rating
6. NSF – National Sanitation Foundation
7. ASTM – American Society for Testing and Materials
8. APWA – American Public Works Association
9. DR – Dimension Ratio
10. DIPS – Ductile iron pipe size
11. CTS – Copper tubing size
12. MEOP – Maximum Expected Operating Pressure

B. Definitions
1. Pressure Rating – the design capacity to safely resist working pressure up to a 73°F maximum service temperature with specified maximum allowances for recurring positive pressure surges above working pressure.
2. Working Pressure Rating – the design capacity to resist working pressure at the anticipated operating temperature with sufficient capacity against the anticipated positive pressure surges above working pressure.
3. Working Pressure – the maximum anticipated, sustained operating pressure applied to the pipe exclusive of transient and surge pressures, also referred to as Maximum Expected Operating Pressure.
4. Surge Pressure – the maximum hydraulic transient pressure increase in excess of the operating pressure that is anticipated in the system as the result of sudden changes in velocity of the water column. Can be further classified as recurring surge pressure (occur frequently and are inherent to the design and operation of the system) or occasional surge pressure (resulting from emergency operations).
5. Restrained Joint –a type of joint designed to resist forces that act to separate a joint, such as thrust caused by internal pressure, external pulling forces, etc. Standard push-on and mechanical joints by themselves do not provide significant restraint against axial thrust forces.

C. Reference Standards
1. ANSI/AWWA (www.awwa.org)
   a. ANSI/AWWA C111 Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
   b. ANSI/AWWA C207 Steel Pipe Flanges For Waterworks Service Sizes 4 Inch Thru 144 Inch (100 Mm Thru 3,600 Mm)
   c. ANSI/AWWA C800 Underground Service Line Valves and Fittings
   d. ANSI/AWWA C901 Polyethylene (PE) Pressure Pipe and Tubing, ½" (13 mm) through 3" (76 mm) for Water Service.
   e. ANSI/AWWA C906 Polyethylene (PE) Pressure Pipe and Fittings, 4" (100 mm) through 63" (1,600 mm), for water distribution and transmission.
   f. AWWA M55 Manual of Water Supply Practices, PE Pipe – Design and Installation.
2. Plastics Pipe Institute, PPI (www.plasticpipe.org)
   a. PPI Handbook of Polyethylene Pipe

b. PPI TN-42 Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Project
c. PPI TR-4 – PPI Listing of Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Strength Design Basis (SDB), Pressure Design Basis (PDB) and Minimum Required Strength Ratings (MRS) for Thermoplastic Piping Materials or Pipe
d. PPI TR-33 – Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe

3. ASTM International (www.astm.org)
   a. ASTM A194 Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature, or Both
   b. ASTM A240 Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications
   c. ASTM D638 Standard Test Method for Tensile Properties of Plastics
   d. ASTM D2683 Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
   e. ASTM D2774 Standard Practice for Installation of Thermoplastic Pressure Piping
   f. ASTM D3035 Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
   g. ASTM D3261 Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
   h. ASTM D3350 Standard Specification for Polyethylene Plastic Pipe and Fittings
   i. ASTM F1055 Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing
   j. ASTM F2164 Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure
   k. ASTM F2206 Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE)
   l. ASTM F2620 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
   m. ASTM F2634 Standard Test Method for Laboratory Testing of Polyethylene (PE) Butt Fusion Joints using Tensile-Impact Method
   n. ASTM F3190 Standard Practice for Heat Fusion Equipment Operator Qualification on Polyethylene and Polyamide Pipe and Fittings
   o. NSF/ANSI 61 Drinking Water Components – Health Effects
4. Unless otherwise specified, references to documents shall mean the latest published edition of the referenced document in effect at the bid date of the project.

1.4 SUBMITTALS

A. Pipe manufacturer’s specific technical data with the complete information on resin, physical properties of pipe and pipe dimensions pertinent to this job.

B. Manufacturer’s specific technical data for all adapters, fittings, couplings, clamps and other appurtenances to be used on the project.

C. Credentials demonstrating training for all fusion operators in accordance with ASTM F3190 for the use of heat fusion equipment and the standard practice for heat fusion joining of HDPE pipe and fittings in accordance with ASTM F2620.

D. Credentials demonstrating training in electrofusion joining by the product pipe manufacturer.

E. Certification of calibration of all fusion equipment per manufacturer's requirements.

F. Certificates of Compliance with Specifications shall be furnished for all materials to be supplied.

G. Classification and MDOT pit number of aggregate for bedding and initial backfill material.

H. Information on reinforcing steel and concrete to be used for concrete restraining blocks.

I. Calculations by a registered professional engineer, licensed in the State of Michigan, for the design thrust force and required length of restrained pipe required to resist the forces in accordance with Article 3.4.

1.5 QUALITY ASSURANCE

A. Visually inspect all pipe, fittings and other materials delivered to the project site for compliance with the specifications and physical condition.
   1. Immediately remove any defective pipe or other materials from the project site.

B. Provide samples of pipe materials at the Owner's request for testing physical properties.
   1. Pipe material property testing will be at the Owner's expense.
   2. Pipe that does not meet the specified properties shall not be used on the project.

C. All phases of pipe fusing operations must be completed by, or under the direct supervision of, qualified fusion technicians who have completed a fusion operator training course offered by a pipe manufacturer, supplier, or fusion equipment manufacturer that is acceptable to the Engineer.

D. Each fusion technician shall be separately qualified to make each type of fusion joint.
   1. Fusion joint types are butt fusion, saddle fusion, and electrofusion.
   2. Qualification to make one type of fusion joint does not qualify a fusion technician to make a different type of fusion joint.

E. The use of electrofusion joining methods is allowable only upon approval by the Owner.

PART 2 PR0DUCTS

2.1 PIPE AND FITTINGS

A. HDPE pipe and fittings for water main shall meet ASTM D3035 and AWWA C906 (4 inch through 63 inch) standards.
   1. All pipe and fittings must be NSF/ANSI 61 and NSF/ANSI 14 listed by the manufacturer and bear the NSF-pw logo or mark.
   2. At a minimum, HDPE pipe used for water main will be DIPS DR 11 (Pressure Class 200 psi) for the nominal diameter specified on the plans.

B. HDPE pipe and fittings for water services shall meet ASTM D3035 and AWWA C901 (3/4 inch through 3 inch) standards.
   1. All pipe and fittings must be NSF/ANSI 61 and NSF/ANSI 14 listed by the manufacturer and bear the NSF-pw logo or mark.
   2. At a minimum, the HDPE pipe used for water services on this project will be CTS DR9 for the nominal diameter specified on the plans.

C. All additional appurtenances (manholes, tees, gaskets, etc.) will meet the material specifications provided in Section 02660 and Section 02661.

D. HDPE pipe will be produced from resins that meet or exceed the requirement of ASTM D3350, designation PE4710, that meets or exceeds a cell classification of PE445574C/E per ASTM D3350.
   1. Material taken from HDPE pipe will meet the minimum stability requirement of ASTM D3350.
   2. Material compound shall have a hydrostatic design stress (HDS) rating for water at 73 degrees F of not less than 1000 psi that shall be listed in PPI TR-4 in the name of the pipe manufacturer.
   3. Material compound shall have a hydrostatic design basis (HDB) rating for water at 140 degrees F of not less than 1600 psi that shall be listed in PPI TR-4 in the name of the pipe manufacturer.
   4. Pipe and fittings shall contain a UV stabilizer to protect the pipe against UV degradation for at least 24 months of unprotected outdoor exposure.
   5. HDPE resin manufacturer to certify the cell classification.

E. Permanently mark pipe at intervals of no more than five (5) feet with the following:
   1. Nominal pipe size and sizing system
   2. Dimension Ratio
   3. ASTM testing designation
   4. HDPE cell classification
   5. Pressure rating or pressure class at 73 degrees F
   6. NSF-pw
   7. Date of manufacture
   8. Point of origin
   9. Manufacturer’s name and trademark,
   10. Example (8” DIPS DR 11, ASTM D3035 PE445574C/E PR200 NSF-pw, ...)

F. Pipe not marked as indicated above will be rejected.

G. Pipe shall be made of virgin material. No rework except that obtained from the manufacturer’s own production of the same formulation shall be used.

H. The pipe shall be homogenous throughout and shall be free of visible cracks, holes, foreign material, blisters, or other deleterious faults.

I. Color pipe with a blue stripe shell and black interior.

J. Pipe and butt fusion fittings shall have plain ends for butt-fusion.

K. Fittings shall be manufactured from the PE4710 resin in accordance with these specifications and may be molded, thermoformed from pipe sections, or fabricated by heat fusion joining HDPE components prepared from pipes, molded fittings, thermoformed pipe or polyethylene sheet or block meeting the requirements of AWWA C901 or AWWA C906.
   1. Molded fittings shall comply with ASTM D3261 for butt and saddle type fusion fittings, flange adapters and MJ adapters.
   2. Fabricated fittings shall comply with ASTM F2206.
      a. Provide test results to validate compliance with Section 7.3 and Section 9.
   3. Socket fittings shall comply with ASTM D2683
   4. Markings on fittings shall comply with the requirements of ASTM D3261 and ASTM F2206; including NSF/ANSI 61 and NSF/ANSI 14, verifying suitability for use in potable water service.
   5. Fittings shall have pressure class ratings not less than the pressure class rating of the pipe to which they are joined.

L. Ductile iron pipe and fittings used in conjunction with HDPE pipe shall meet the requirements provided in Section 02661.

2.2 MJ ADAPTERS AND FLANGE ADAPTERS

A. Fittings described in this Article include all fittings intended to be joined to HDPE piping by thermal heat fusion that have one or more parts for effecting a mechanical connection, such as mechanical-joint (MJ) or flange, to ductile iron or other type of piping.

B. Fittings will be produced from resins that meet or exceed the requirements of ASTM D3350, designation PE4710 and specifically made for use on municipal water systems.

C. Each fitting shall be designed and manufactured to operate at not less than the Pressure Class of the pipe system for which it is intended.

D. Backup rings, flanges or glands shall be made of stainless steel or suitably coated steel or ductile iron.
   1. MJ glands shall conform to AWWA C111.
   2. All flange dimensions, except thickness, shall conform to AWWA C207 to ensure they mate with other inline components.
   3. Support provided thickness with calculations made by the backup ring supplier for the specified pressure rating, and provide upon request.
   4. Pressure ratings provided in AWWA C207 do not apply to HDPE piping systems.

E. Rubber gaskets shall be made of vulcanized styrene butadiene rubber (SBR), meeting the requirements of AWWA C111.

2.3 ELECTROFUSION COUPLINGS AND FITTINGS

A. Fittings described in this Article include all couplings and fittings intended to be joined to HDPE piping by electrofusion means.

B. Electrofusion fittings will be produced from resins that meet or exceed the requirements of ASTM D3350, designation PE4710, and specifically made for use on municipal water systems.

C. Electrofusion-type molded fittings shall meet the requirements of ASTM D2683 for socket-type fittings and ASTM F1055.

D. Markings on fittings shall comply with the requirements of ASTM F1055; including NSF-pw verifying suitability for use in potable water service.

E. Each fitting shall be designed and manufactured to operate at not less than the Pressure Class of the pipe system for which it is intended.

F. All electro-fusion fittings shall be AWWA approved.

2.4 MECHANICAL COUPLINGS, CLAMPS AND JOINT RESTRAINT SYSTEMS

A. Couplings, clamps or other fittings and joint restraint systems that rely on purely mechanical means for securing the connection to HDPE water main pipe are prohibited.

2.5 HARDWARE

A. Bolts and nuts for all fittings shall meet the following requirements unless superior hardware (as determined by the Owner) is specified elsewhere
   1. Manufactured of low alloy steel conforming with the material characteristics listed in ANSI/AWWA C111.
   2. Coated with a minimum two (2) coats of fluoropolymer epoxy coating and heat cured.
   3. Manufacturers
      a. Cor-Blue by Birmingham Fasteners
      b. R-Blue by Romac Industries
      c. Owner approved equal

2.6 SERVICE SADDLES

A. Service saddles shall have a ductile iron body, fusion plastic coated, and double, stainless steel straps meeting the requirements of AWWA C800.
   1. Straps, bolts, nuts and washers shall stainless steel 18-8 Type 304.
   2. Passivate all welds for resistance to corrosion
   3. Minimum working pressure of 250 psi
   4. Service saddles on pipe less than 14-inches in diameter
      a. Minimum combined strap width of 3-1/4-inches
   5. Service saddles on pipe from 14-inch to 24-inch in diameter
      a. Two straps a minimum of 2-3/4 inches wide

B. Manufacturers
   1. JCM 406 by JCM Industries
   2. Owner approved equal

2.7 TRACER WIRE

A. Where called for on the Plans, provide tracer wire as follows:
   1. For water main installed by pipe bursting methods, use tracer wire made of solid or multi-strand copper, copper-clad steel encased within an HDPE jacket designed for 600-volt applications with a 45 mil minimum thickness designed specifically for use in direct burial applications.
      a. Jacket color shall be blue per APWA color coding convention.
      b. Tracer wire used for pipe bursting shall have a minimum tensile strength/break load of 3,500 pounds and shall be specifically designed for pipe bursting applications.
   2. For water main installed by horizontal directional drilling methods, use tracer wire made of solid or multi-strand copper, copper-clad steel, or stainless steel encased within an HDPE jacket designed for 600-volt applications with a 45 mil minimum thickness designed specifically for use in direct burial applications.
      a. Jacket color shall be blue per APWA color coding convention.
      b. Tracer wire used for horizontal directional drilling shall have a minimum tensile strength/break load of 2,500 pounds and shall be specifically designed for horizontal directional drilling applications.
   3. For other installation methods, use 10 AWG copper wire with a minimum 30 mil coating.
   4. The minimum thickness at any point along the tracer wire shall not be less than 90% of the specified average thickness in compliance with UL 83.
      a. UL 83 specification shall be clearly marked on the wire insulation.

B. Provide test stations that are compatible with Owner's locating equipment.
   1. For test stations not located within a gate well, provide a heavy-duty tracer box with cast iron cover.
   2. Tracer boxes in pavement shall be flush-mounted and rated for traffic.

C. Attach two (2) separate tracer wires to the water main at 5-foot intervals along the full length between test stations.
   1. Utilize plastic cable ties or Owner approved alternative to attach the tracer wires to the pipe.
   2. The use of tape is prohibited.

D. Provide manufactured connectors that are rated for direct burial, have a dielectric gel and are sealed.

E. Provide magnesium anodes for grounding all dead ends of tracer wire not brought to a test station.

F. Check tracer wires for continuity prior to placing the water main into service.

2.8 PIPE BEDDING

A. Bedding aggregate to meet grading requirements as specified below.

B. Delineated as material between the bottom of the trench and the spring line of the pipe.

C. Material shall be a minimum 95% crushed in accordance with MTM 117, unless otherwise approved by the Owner.

D. When bedding HDPE pipe, the maximum particle size of the bedding aggregate is dependent on the nominal diameter of the pipe being installed and are as follows;
   1. Less than 6-inch diameter; Maximum Particle Size = 1/2-inch
   2. 6-inch diameter to 8-inch diameter; Maximum Particle Size = 3/4-inch
   3. 10-inch diameter to 15-inch diameter; Maximum Particle Size = 1-inch
   4. 16-inch diameter and above; Maximum Particle Size = 1 1/2 -inch

E. Slag and crushed concrete aggregates are prohibited.

F. Aggregates to be supplied from approved manufacturers of prequalified aggregate sources, as identified in the MDOT Materials Source Guide, latest edition.

BEDDING MATERIAL
GRADING REQUIREMENTS

Material	Total Percent Passing (Sieve Size)							
	1 ½"	1"	3/4"	1/2"	3/8"	No. 4	No. 8	Loss by Washing
MDOT 6A*	100	95-100	-	30-60	-	0-8	-	≤ 1.0
MDOT 17A*	-	100	90-100	50-75	-	0-8	-	≤ 1.0
MDOT 25A	-	-	100	95-100	60-90	5-30	0-12	≤ 3.0
MDOT 34G	-	-	-	100	95-100	-	0-5	≤ 3.0

* Requires Owner Approval

2.9 INITIAL BACKFILL

A. Aggregate used for Initial Backfill shall match the requirements of the Bedding material used.

B. Delineated as material between the springline of the pipe and 12-inches above the top of the pipe.

C. The use of excavated or borrow material from site or materials meeting any of the criteria of "Unsuitable Material" as described in Section 02315 is prohibited.

2.10 CONCRETE RESTRAINING BLOCK

A. MDOT Concrete Grade S2 with a minimum compressive strength of 3,500 psi.

2.11 FUSION EQUIPMENT

A. Contractor owned fusion equipment must be calibrated and certified per the pipe manufacturer's requirements and in satisfactory working order with a leak-free hydraulic system.
   1. Provide heater plates with a consistent clean coated surface free from scrapes and gouges.
   2. Check pressure gauge and thermometer for accuracy.
   3. Provide record of maintenance service/inspection from the past 3 months.

B. Rental fusion equipment

1. Must be maintained by a certified Service and Repair Center.
2. Provide record of maintenance service/inspection from the past 3 months.

2.12 SOURCE QUALITY CONTROL

A. Provide samples of pipe materials at the Owner's request for testing physical properties.
   1. Pipe property testing will be at the Owner's expense.
   2. Pipe that does not meet the specified properties shall not be used on the project.

B. Provide two (2) trial butt fusion samples for each fusion operator for bent strap testing per method described in Chapter 2 of the PPI Handbook of Polyethylene Pipe before pipe fusing production begins.
   1. Bent strap testing will be at the Contractor's expense.
   2. If a failure occurs, fusion procedures and machine set up must be reviewed and changed, and a new trial fusion and bent strap test specimen be prepared and tested.
   3. Field fusion will not proceed until all operators successfully demonstrate the ability to produce a quality joint.
   4. Trial fusion and bent strap testing, along with any retesting, will be completed at no expense to the Owner.
   5. Any delay to the project schedule due to complying with this testing will not be cause for contract time extension.

C. Provide representative samples of completed butt fusion joints for tensile strength testing per ASTM D638 and ASTM F2634.
   1. Pipe joint strength testing will be at the Owner's expense.
   2. If the representative sample does not meet the specified tensile strength requirements, all butt fusion joints completed in a similar manner to that from which the sample was taken shall be cut-out and replaced at no expense to the Owner.

PART 3 EXECUTION

3.1 DELIVERY, HANDLING, AND STORAGE

A. Deliver and unload pipe in a manner such that damage to the pipe or coatings is prevented.
   1. Cover pipe with tarpaulins to minimize exposure to diesel exhaust or smoke during delivery.
   2. Materials found to be defective, damaged or unsound at the time of delivery will be rejected and must be removed from the project site.

B. Unload pipe from trucks and handle using a suitable lifting device with slings or padded forks or hooks to prevent damage to the coated exterior surface or internal lining of the pipe.
   1. Handle pipe in accordance with PPI Handbook of Polyethylene Pipe Chapter 2.

C. Neatly stack pipe using timbers and chock blocks to prevent bottom tiers from resting on the ground.

1. Stacks shall not exceed six feet in height.

D. Protect stored pipe materials against deterioration from exposure to ultraviolet light and weathering effects.

E. Store materials in areas designated by the Owner.
1. Do not store pipe near heat sources.
2. Maintain all sealing surfaces of mating components (i.e. flange faces) free from dirt or debris at all times.
3. Security for stored materials is the responsibility of the Contractor.

F. Handle the pipeline in such a manner that it is not damaged by dragging it over sharp and cutting objects.
1. Materials found to be damaged at the point of installation will be rejected and must be removed from the project site.
2. Cuts, punctures, or gouges that penetrate or reduce the wall thickness by 10% or more are not acceptable.

G. Cold weather reduces flexibility of pipe materials and increases vulnerability to impact damage. Additional care must be taken in these conditions to protect the pipe during handling.

3.2 INSTALLING PIPE

A. Where HDPE water main pipe is specified to be installed by pipe bursting, horizontal directional drilling or compression fit pipe lining methods, refer to those related Sections for information pertaining to the specified method.

B. For underground installation of HDPE water main pipe in excavations or trenches, install pipe in accordance with AWWA M55 and ASTM D2774.

C. Complete trenching and excavation in accordance with Section 02315, with the following specific requirements pertaining to installation of HDPE pipe:
1. The minimum width of trench at top of pipe shall be;
a. Nominal pipe diameter plus 12 inches for pipes between 4 inches in diameter and 24 inches in diameter.
b. Nominal pipe diameter plus 24 inches for pipe greater than 24 inches in diameter
2. Maximum trench width should not exceed the minimum trench width by more than 18 inches plus the thickness of any sheeting, shoring or shielding.
3. Excavate trench a minimum of 4 inches minimum below the outer surface of the pipe.
4. Place pipe bedding material to the centerline of the pipe.
5. Place initial backfill material to 12 inches above the top of the pipe.

D. The interior of each pipe shall be inspected for cleanness and cleared of all dirt and foreign matter before being lowered into the trench.

E. When the temperature is above 60 degrees, allow the pipe to sufficiently cool and thereby contract before making connections to an anchored joint, flange or fitting that requires protection against excessive pull-out forces.

F. Whenever deflections at joints are required by changes in grade or alignment, the deflection at any mechanical joint shall not exceed three-quarters of the maximum deflection recommended by the manufacturer of the joint used.

G. The minimum cold bending radius for HDPE pipe shall not be less than 30 times the outside diameter of the pipe.
   1. Minimum cold bending radius at fittings to be installed in a bend shall not be less than 100 times the outside diameter for a length of 5 times the outside diameter on either side of the fitting location.

H. Where necessary to cut pipe, cutting shall be done with approved tools and cut ends of pipe shall be square and regular.

I. To prevent trench water from entering the pipe which for any reason may not be completed as the pipe is laid shall be thoroughly packed with approved material, in a manner to make them watertight. Open ends of fittings shall be tightly closed with approved plugs and well packed as shall the end of the last pipe laid whenever work is not in progress.

J. Tools or other objects shall not be stored or left in the pipe.

3.3 JOINING PIPE

A. The polyethylene pipe and fittings shall be assembled and joined at the site by heat fusion, manufactured transitions or adapters, or mechanical fittings to provide a leak-free system.
   1. Threaded or solvent-cement joints and connections are not permitted.
   2. All equipment and procedures used shall be used in strict compliance with the manufacturer's recommendations.

B. Pipe joining by heat fusion methods shall be accomplished by personnel certified as fusion technicians by a manufacturer of polyethylene pipe and/or fusing equipment for each type of fusion being performed.

C. During inclement weather, construct a temporary shelter around the joining operation to shield from rain, frozen precipitation, and high winds. During cold weather, area may need to be heated to assure proper fusion.

D. Pipe joining by butt fusion shall be completed considering the following:
   1. Use a fusion machine capable of aligning pipe ends, clamping the pipe, facing the pipe ends parallel and square to the centerline, heating the pipe ends, and applying the proper fusion force.
   2. Joints shall be true alignments and have uniform roll-back beads resulting from the use of proper temperature and pressure. The joint shall be allowed adequate cooling time before removal of pressure.
   3. Maintain a log of every fused joint, including a record of the fusion operator name, date, time, joint identification number, ambient temperature and weather conditions, equipment heating temperature, force or pressure applied, and cooling time.
   4. The fused joint shall be watertight and have tensile strength equal to that of the pipe and be free of visual defects such as blisters or inclusion of foreign material.
   5. Provide samples of fused joints at the request of the Owner.

6. All joints shall be subject to acceptance by the Engineer prior to insertion.
7. All defective joints shall be cut out and replaced at no cost to the Owner.

E. Pipe joining by electrofusion shall be completed considering the following:
1. Prepare the pipe by scraping and cleaning in accordance with the electrofusion fitting manufacturer's recommended procedures. Use tools specifically designed for this purpose.
2. Wipe area of pipe being joined with 90% isopropyl alcohol.
3. Align and restrain pipe being joined per manufacturer's procedures.
4. Cut and face ends of pipe being joined so they are properly located between heating elements of the fitting.
5. Apply electric current as required by manufacturer's procedures.
6. Allow pieces to cool sufficiently before removing any clamps or restraints per manufacturer's procedures.
7. Maintain a log of every fused joint, including a record of the fusion operator name, date, time, fitting location, ambient temperature and weather conditions, current applied, equipment heating temperature, and cooling time.
8. The fused joint shall be watertight and have tensile strength equal to that of the pipe. All defective joints shall be cut out and replaced at no cost to the Owner.
9. All joints shall be subject to acceptance by the Engineer prior to insertion.

F. Pipe joining by use of manufactured adapters or transitions shall be completed considering the following:
1. Manufactured adapter or transition shall be fused to the pipe end by butt fusion or electrofusion coupling, completed as described in Article 3.3.D and 3.3.E, respectively.
2. Install gaskets in accordance with fitting manufacturer's procedures.
3. Tighten bolts in accordance with fitting manufacturer's procedures.
4. The completed joint shall be watertight and fully restrained.
5. All defective joints shall be disassembled and replaced or reinstalled at no cost to the Owner.

3.4 SYSTEM RESTRAINT

A. Restrained joints shall be used on all ductile iron pipe segments, fittings, hydrants and gate valves inline with HDPE pipe installations.
1. Install in accordance with Section 02660 and Section 02661 of the Specifications.
2. Install thrust blocks at hydrants and fittings where required by the Owner.

B. When making a connection to an unrestrained part of the water main system, whether the existing mains at the limits of the project or within the new pipe system, install inline pipe restraint measures to prevent unrestrained joints from pulling apart. Methods for inline pipe restraint may include one or more of the following:
1. Install flex restraint fittings and concrete restraining block per the Owner's Standard Details.
a. Allow for an adequate period of time for concrete curing before pressurizing the main.
2. Excavate an appropriate number of unrestrained joints and install restraint harnesses on each joint.

a. Provide an analysis by a registered professional engineer, licensed in the State of Michigan, calculating the design thrust force and the required length of restrained pipe required to resist it.
b. Backfill and restore disturbed surfaces.

3.5 PIPE BEDDING

A. Prior to placement of bedding materials, remove any rocks, stones, dirt clods and debris larger than the maximum specified particle size from the trench.

B. Place the required depth of bedding material on the trench subgrade that will rest below the utility bottom.
1. Do not compact the Inner Bedding.
2. Carefully excavate bell or coupling holes from this bedding layer so that the bells or couplings support no part of the load and the pipe barrel lies flat on the trench bottom.

C. Install utility
1. To line and grade as specified in the construction drawings.
2. Refer to specific pipe material specification for installation requirements.

D. Place Haunch Bedding to the springline of the utility.
1. Distribute bedding material evenly along the trench and equally on both sides of the pipe to maintain alignment.
2. Shovel slice material to occupy voids along the bottom circumference of the utility.
3. Hand tamp and consolidate material to minimize voids in lifts not exceeding 6 inches.
a. The use of mechanical compaction equipment is prohibited.
b. Monitor compaction efforts so as to not raise pipe during consolidation.
4. At no time should there be more than one lift thickness difference in elevation of the material on one side of the pipe from the other.

E. Place remainder of Bedding material, if specified, and hand tamp to minimize voids in lifts not exceeding 6 inches.

F. Under no circumstance shall bedding materials be dropped or dumped into the trench.

G. Blocking under pipe is strictly prohibited.

H. Wrap the Pipe Zone with a geotextile separator when installing the utility beneath the ground water table in locations where the rapid movement of groundwater may result in the migration of soil fines into, out of, or between layers of the bedding material.

I. Bedding in Rock Excavations:
1. Utilities
a. A minimum of 6 inches of foundation cushioning is required between the bottom of the utility and the trench subgrade.
b. A minimum of 12 inches of clearance is required between the sides of the utility and the walls of the trench.
2. Appurtenant Structures

a. A minimum of 8 inches of foundation cushioning is required between the bottom of manhole bases and other precast structures and appurtenances, and the trench subgrade.
b. A minimum of 18 inches of clearance is required between the sides of the structures and appurtenances and the walls of the excavation.

3.6 INITIAL BACKFILL

A. Inspect pipe and fittings prior to Initial Backfill.

B. Place Initial Backfill immediately after acceptance of utility Bedding compaction to protect the new utility installed.

C. Observe specific pipe manufacturer's recommendations regarding methods of backfilling and compacting.

D. Place Initial Backfill in lifts not exceeding 6 inches (loose thickness).

E. Simultaneously fill the trench on both sides of the pipe in such a manner that injurious side pressures do not occur such that the pipe could be displaced or dislodged.

F. Hand place, shovel slice, and hand tamp each lift of initial backfill solidly around and directly above the pipe.
1. Utilize hand tamping to compact materials around the pipe.
2. Do not use mechanical compaction equipment during Initial Backfill operations until material has been brought to 12 inches above the top of the pipe barrel.

G. Exercise extreme care in backfilling operations to avoid displacing joints and appurtenances or causing any horizontal or vertical misalignment, separation, distortion or damage to newly made joints.

H. Compact the top of the Initial Backfill to not less than 95% of the maximum unit weight of the selected material as specified in Article 1.5.

I. Refer to specific pipe material specification for additional initial backfill requirements.

J. Remove and replace utility if broken or damaged during backfill installation and compaction.

K. Repair damages, distortions, or misalignments that occurred during backfill installation and compaction, to the full satisfaction of the Owner.

L. Do not enclose or cover up any of the Work prior to required inspections and quality control testing.

3.7 BACKFILL AND COMPACTION

A. Backfill and compact water main trench in accordance with Section 02315.

3.8 PIPE AND JOINT TESTING

A. Provide samples of pipe materials at the Owner's request for testing physical properties. Pipe property testing will be at the Owner's expense. Pipe that does not meet the specified properties shall not be used on the project.

B. Provide butt fusion samples for each fusion operator as detailed in Article 2.12.

C. Provide representative samples of completed butt fusion joints at the Owner's request for tensile strength testing as detailed in Article 2.12.

3.9 HYDROSTATIC PRESSURE TESTING

A. Refer to Section 02660 for general acceptance testing and hydrostatic testing requirements.

B. Before connection of installed water main to the municipal system is allowed, complete a hydrostatic pressure test of the system in accordance with ASTM F2164. The specified test pressure is 150 psi or 1.5 times the MEOP of the test section, whichever is greater. The test method is generally summarized as follows:
   1. Zero leakage allowed.
   2. The ambient air temperature and surface temperature of the pipe must be considered and adjustment to test pressure may be appropriate.
   3. Slowly fill the test section with water and carefully and completely exhaust all of the air from the test section.
   4. Allow time for test fluid and pipe temperature to equalize.
   5. Allow for initial expansion as full test pressure is applied. The initial expansion phase is four hours.
   6. Reduce pressure by 10 psi, observe target test pressure for one hour, and if the pressure remains within 5% of the target test pressure, then a passing test is indicated.
   7. If leaks are detected, depressurize main and repair as needed. Allow the test section to remain depressurized for 8 hours before retesting.

3.10 FLUSHING, CLEANING, AND DISINFECTION

A. Disinfect the water main system in accordance with ANSI/AWWA C651 and as described in Section 02660, except that the disinfection solutions containing chlorine must not exceed 12 percent active chlorine.

B. Duration of disinfection should not exceed 24 hours.

C. Thoroughly flush system with fresh water upon successful completion of sampling.

D. Sample again to verify the disinfectant chlorine level has been reduced to potable drinking water concentrations.

3.11 WATER SERVICE CONNECTIONS

A. Refer to Section 02660 for general water service connection and installation requirements.

B. Use mechanical service saddle as specified to make all service connections.
   1. Electrofusion tapping saddles are prohibited.
   2. Confirm proper size and range of the service saddle

3. Clean and scrape pipe to remove any scale, debris or dirt that may interfere with the complete sealing of the gasket.
4. Lubricate the pipe and the fitting gasket with soapy water, do not use an oil base lubricant.
5. Position service saddle on pipe, making sure outlet is aligned with the branch line to be connected.
    a. Do not position so that rotation is required
    b. Rotation may result in gasket dislocation.
6. Install straps and bolts
    a. Make sure gasket is in the proper position and not in the waterway.
    b. Refer to manufacturer's guidelines for stainless steel fastener management.
7. Tighten bolts per manufacturer's recommended guidelines

END OF SECTION