Municipal Advisory Board

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MAB Model Specifications for PE 4710 Buried Potable Water Service, Distribution and Transmission Pipes and Fittings

(MAB-3-2017)

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FOREWORD

This model specification was developed by the Municipal Advisory Board (MAB) and published with the help of the members of the Plastics Pipe Institute, Inc. (PPI).

This model specification is intended as a guide for engineers, users, contractors, code officials, and other interested parties for use in the design, construction, and installation of high density polyethylene (HDPE) pressure water piping systems. The local utility or engineer may need to modify this model specification to adapt the document to local conditions, operations, and practices.
This model specification has been prepared by MAB members and associates as a service to the water industry. The information in this document is offered in good faith and believed to be accurate at the time of its preparation, but is offered "as is" without express or implied warranties, including WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. Any reference to a specific manufacturer's product is merely illustrative, and not intended as an endorsement of that product. Reference to or testing of a proprietary product should not be construed as an endorsement by the MAB or PPI, which do not endorse the proprietary products or processes of any manufacturer. Users are advised to consult the manufacturer for more detailed information about the specific manufacturer's products. The information in this document is offered for consideration by industry members in fulfilling their own compliance responsibilities. MAB and the PPI assume no responsibility for compliance with applicable laws and regulations.

The MAB serves as an independent, non-commercial adviser to the Municipal & Industrial (M & I) Division of the PPI. Once adopted, MAB will consider revising this specification from time to time, in response to comments and suggestions from users of the model specification. Please send suggestions of improvements to Camille George Rubeiz, PE, F.ASCE, at crubeiz@plasticpipe.org.

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MAB Model Specifications for PE 4710

Buried Potable Water Service, Distribution and Transmission Pipes and Fittings

PART 1 – GENERAL

1.1 The scope of this model specification is for HDPE water piping systems that conform to AWWA standards. This model specification can be adopted in full, or modified by the specifier to fit the project. This model specification provides minimum requirements for PE 4710 pipe and fittings to be used in the design and construction of pressure water piping systems.

1.2 DESCRIPTION

A. Scope – This section specifies high-density polyethylene pipe (HDPE) and fittings for water utility use as indicated on the drawings, and as specified herein.
   i. Furnish, install, and test HDPE piping system as indicated and specified in this section, as referred to in related sections, and as shown in the Drawings.
   ii. The primary installation method is direct burial. The means and methods, including the testing for acceptance shall conform to all applicable standards as noted herein with the intention of providing a leak-free system to the owner.

1.3 REFERENCES

A. To the extent referenced in this specification section, the standards and documents listed in Appendix A are included and are made part of this specification.
B. In the event of a conflict, the requirements of this specification section prevail.
C. 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 SYSTEM DESIGN PARAMETERS

A. Per AWWA C901, C906 and M55, the Allowable Total Pressure during Recurring Surge conditions equals 1.5 times the pipe's pressure class. Allowable Total Pressure during Occasional Surge conditions equals 2.0 times the pipe's pressure class.
B. Table 1 lists the preferred pressure classes, Allowable Total Pressure during Recurring and Occasional Surges for PE4710. ***Note****: AWWA defines pressure class (PC) differently for different pipe materials, i.e., PC for ductile iron and PVC is different from that for HDPE. For further information on the proper selection of pressure class, visit PPI PACE and Tables 1 and 2.*
C. Water Hammer
   i. Fatigue: Use minimum 55 cycles per day for 100-year fatigue design life.
   ii. Flow Velocity: Use minimum 4 fps for recurring surge design and minimum 8 fps for occasional surge design.

Table 1: PE4710 Preferred Pressure Classes per AWWA C906 and C901 (up to 80ºF)

Pipe Dimension Ratio (DR)	Pressure Class / Rating (psi)	Allowable Total Pressure during Recurring Surge (psi)	Allowable Total Pressure during Occasional Surge (psi)	AWWA C906	AWWA C901	Allowable Hydrotest Pressure (psi)
DR 17	125	188	250	Yes	No	188
DR 13.5	160	240	320		No	240
DR 11	200	300	400		No	300
DR 9	250	375	500		Yes	375

Table 2: Required Pressure Class (PC) and Dimension Ratio (DR) for PE4710, PVC and DI*

Working Pressure	PE4710 PC (DR)	PVC PC (DR)	Ductile Iron PC
75 psi	PC125 (DR17)	PC305 (DR14)	PC350

***Example**: In accordance with AWWA standards and manuals and per PPI PACE: Calculate the required PC for 8" DIPS PE4710, PVC and Ductile Iron pipes operating at 75 psi working pressure, with 4 fps recurring surge, 8 fps occasional surge, 55 cycles per day for 100 years and at 73ºF temperature.

1.5 SUBMITTALS

A. Quality Assurance / Control Submittals

i. Affirmation that product shipped meets or exceeds the standards set forth in this specification. This shall be in the form of a written document from the manufacturer attesting to the manufacturing process meeting the standards. *[The specifier can also ask for various test results to be supplied that are done according to the standards]*

ii. Manufacturers recommended fusion procedures for the products.

1.6 DELIVERY – STORAGE – HANDLING

A. Handle the pipe in accordance with the PPI *Handbook of Polyethylene Pipe, Chapter 2* using approved strapping and equipment rated for the loads encountered. Do not use chains, wire rope, forklifts or other methods or equipment that may gouge or damage the pipe or endanger persons or property. Field storage is to be in compliance with AWWA Manual M55, Chapter 7.

B. Shipped with optional, recyclable, end-caps (suggested)

C. If any gouges, scrapes, or other damage to the pipe results in wall loss 10% or greater (of the pipe wall thickness), cut out that gouged section and do not use.

PART 2 – HDPE PRODUCTS FOR 4 INCH AND LARGER PIPE PER AWWA C906

2.1 – PIPE

A. HDPE pipe with 4" to 65" diameter shall be PE4710 conforming to the latest edition of ANSI/AWWA C906 and ANSI/NSF Standard 61. For potable water applications, PE4710 compound shall conform to ASTM D3350 minimum Cell classification *445574C-CC2* or CC3. Refer to PPI TN-44 for CC2 and CC3 calculations to determine which classification is required.

i. HDPE pipes shall be extruded by a PPI member and shall meet the requirements of AWWA C906. Sample list of sizes is shown in Appendix B.1.

ii. Dimensions and tolerances for HDPE pipe and fittings shall meet the requirements of AWWA C906.

B. HDPE pipe shall be rated for use at a pressure class of _____ *[User specified]* psi. *[The specifier chooses the pressure class from Table 1]*. The outside diameter of the pipe shall be based upon the IPS or DIPS sizing system. *[User to specify the appropriate sizing system on the plans.]*

C. Pipe marking in accordance with Section 2.3.

D. Approved manufacturers are: [*The specifier is referred to the list of manufacturers as shown on the PPI website http://plasticpipe.org/municipal_pipe/mid-members.php].*

2.2 FITTINGS

A. Butt Fusion Fittings – HDPE Fittings shall be made of PE4710 and with a minimum Cell Classification as shown in Section 2.1.A. HDPE molded and fabricated fittings shall have a pressure rating equal to the pipe unless otherwise specified on the plans. All HDPE fittings shall meet the requirements of AWWA C906 and shall have a pressure rating equal to the pressure rating of the pipe to which the fitting is joined.
   i. Molded fittings shall be manufactured, tested and marked per ASTM D3261.
   ii. Fabricated fittings shall be manufactured, tested and marked per ASTM F2206, or individual fittings standards.
   iii. Socket fittings shall meet ASTM D2683.

B. Electrofusion Fittings - Fittings shall be made of HDPE material with a minimum material designation code of PE 4710 and with a minimum Cell Classification as noted in 2.1A. Electrofusion Fittings shall have a manufacturing standard of ASTM F1055. Fittings shall have a pressure rating equal to the pipe unless otherwise specified on the plans. All electrofusion fittings shall be suitable for use as pressure conduits and shall be pressure rated equal to the pressure rating of the pipe to which it is joined. Markings shall be according to ASTM F1055.

C. Flanges and Mechanical Joint adapters (MJ adapters) – Flanges and MJ adapters shall have a material designation code of PE4710 with a minimum Cell Classification as noted in 2.1.A. Flanges shall be made in accordance with ASTM F2880. MJ adapters shall be made to ASTM D3261. Flanges and MJ adapters shall have a pressure rating equal to the pipe to which it is joined unless otherwise specified on the plans. Markings for molded or machined flange adapters or MJ adapters shall be per ASTM D3261. MJ adaptors are the preferred connection method over mechanical fittings. Flanges and MJ adaptors should be double checked for butterfly valve clearance to allow full disc rotation and movement prior to installation in the trench.

D. Mechanical Fittings for pipes - Three primary mechanical fittings or connections that can be used are Stab or insert type; compression type; and clamp ring. Some mechanical fittings are designed to be used without stiffeners and other mechanical fittings may require the use of stiffeners. Consult the fittings manufacturer for recommendations on whether a stiffener is required. Mechanical fittings shall be engineered to prevent sliding or rotation movement.

2.3 PIPE AND FITTING IDENTIFICATION

A. The pipe shall be marked in accordance with the standards to which it is manufactured. *[or alternative as above]* .
   Markings shall include the following items: Nominal size (such as 12"), outside diameter base (such as DIPS), dimension ratio (such as DR 17), manufacturer's name or trademark, standard materials designation code (PE 4710), cell classification (e.g. PE 445574C), PE compound oxidative resistance for potable water (such as CC2), pressure class (such as PC 125), standard's designation (AWWA C906), manufacturer's production code, date of manufacture, mark of the certifying agency for potable water (such as NSF).

B. Color identification by the use of stripes on pipe to identify pipe service is recommended. If used, stripes or colored exterior pipe product shall be blue for potable water. Fittings are typically not striped.

C. Marking tape shall be approved by the engineer and placed between 6 and 12 inches above the crown of pipe.

PART 3 – HDPE PRODUCTS FOR 3 INCH AND SMALLER PIPE PER AWWA C901

3.1 PIPE

A. HDPE pipe with ¾" to 3" diameter shall be PE 4710 conforming to the latest edition of ANSI/AWWA C901 and ANSI/NSF Standard 61. For potable water applications, PE4710 compound shall conform to ASTM D3350 minimum Cell classification *445574C-CC3;* refer to ASTM D3350 for other cell classifications and to PPI TN-49 for CC3 calculations.

B. Dimensions and tolerances for pipe and fittings shall meet the requirements of AWWA C901. Sample list of sizes is shown in Appendix B.2.

C. Per AWWA C901, PE4710 tubing shall have a pressure class of 250 psi. The outside diameter of the pipe shall be based upon the IPS or CTS sizing system. *[User to specify the appropriate sizing system on the plans.]*

D. Approved manufacturers are: [*The specifier is referred to the list of manufacturers as shown on the PPI website http://plasticpipe.org/municipal_pipe/mid-members.php*]

3.2 FITTINGS

A. Butt Fusion Fittings - Fittings shall be made of PE4710, with a minimum Cell Classification as noted in 3.1.A. Butt Fusion Fittings shall meet the requirements of ASTM D3261. Molded and fabricated fittings shall have a pressure rating equal to the pipe unless otherwise specified in the plans.

B. Markings for molded fittings shall comply with the requirements of ASTM D3261. Fabricated fittings shall be marked in accordance with ASTM F2206. Socket fittings shall meet ASTM D2683.

C. Electrofusion Fittings - Fittings shall be PE4710, with a minimum Cell Classification as noted in 3.1.A. Electrofusion Fittings shall have a manufacturing standard of ASTM F1055. Fittings shall have a pressure rating equal to the pipe unless otherwise specified on the plans.

D. Flanges and Mechanical Joint adapters (MJ adapters) – Flanges and MJ adapters shall be PE4710, with a minimum Cell Classification as noted in 3.1.A. Flanged and MJ adapters can be made to ASTM D3261 or if machined, must meet the requirements of ASTM F2206. Flanges and MJ adapters shall have a pressure rating equal to the pipe unless otherwise specified on the plans. Markings for molded or machined flange adapters or MJ adapters shall be per ASTM D3261. Fabricated (including machined) flange adapters shall be per ASTM F2206.

E. Mechanical Fittings for service tubes - Three primary mechanical fittings or connections can be used, which are: Stab or insert type; compression type; and clamp ring. Some mechanical fittings are designed to be used without stiffeners and other mechanical fittings may require the use of stiffeners. Consult the fittings manufacturer for recommendations on whether a stiffener is required.

F. Mechanical fittings shall be engineered to prevent sliding or rotation movement.

G. Service connections shall be electrofusion saddles with a brass or stainless steel threaded outlet, electrofusion saddles, sidewall fusion branch saddles, tapping tees, or mechanical saddles.

H. For electrofusion saddles with threaded outlet the size of the outlet shall be as shown on the plans. Electrofusion saddles shall be made from materials required in part 3.1.A.

I. For sidewall fusion saddles, the size of the saddle shall be as indicated on the plans. The saddle can be made in accordance to ASTM D3261 or ASTM F2206.

J. Tapping tees shall be made to ASTM D3261 or D2683 and MSS SP-60.

3.3 PIPE AND FITTING IDENTIFICATION

A. The pipe shall be marked in accordance with the standards to which it is manufactured. *[or alternative as above]* .
Markings shall include nominal size, outside diameter base (e.g. CTS), dimension ratio (e.g. DR 9), manufacturer's name or trademark, standard materials designation code (PE 4710), cell classification (e.g. PE 445574C), PE compound oxidative resistance for potable water (CC3), pressure class (PC 250), standard's designation (AWWA C901), manufacturer's production code, date of manufacture, mark of the certifying agency for potable water (such as NSF).

B. Color identification by the use of stripes on pipe to identify pipe service is recommended. If used, stripes or colored exterior pipe product shall be blue for potable water. Fittings are typically not striped.

C. Marking tape shall be approved by the engineer and placed between 6 and 12 inches above the crown of pipe.

<u>PART 4 – EXECUTION</u>

4.1 TRAINING AND INSPECTION

A. Refer to ASTM F3190, PPI TN-42, MAB-01and MAB-02 for recommended training and inspection for butt-fusion, socket fusion and Electrofusion joints. All equipment shall be inspected and personnel training requirements completed and verified prior to commencing construction.

4.2 JOINING METHODS

A. Butt Fusion: The preferred method to join pipe shall be the butt fusion procedure outlined in ASTM F2620 or PPI TR-33. All fusion joints shall be made in compliance with the pipe or fitting manufacturer's recommendations. Fusion joints shall be made by qualified fusion technicians per PPI TN-42 and ASTM F3190.

B. Saddle fusion: Saddle fusion shall be done in accordance with ASTM F2620 or TR-41 or the fitting manufacturer's recommendations and PPI TR-41. Saddle fusion joints shall be made by qualified fusion technicians. Qualification of the fusion technician shall be demonstrated by evidence of fusion training within the past year on the equipment to be utilized on this project. *[Saddle fusion is used to fuse branch saddles, tapping tees, and other HDPE constructs onto the wall of the main pipe]* (ASTM F905).

C. Socket Fusion: Molded socket fusion fittings are only to be used for joining of HDPE pipe from ¾ inch to 2 inch size. Socket fusion shall be done in accordance with ASTM F2620 or the fitting manufacturer's recommendations. Socket fusion is the process of fusing pipe to pipe, or pipe to fitting by the use of a male and female end that are heated simultaneously, and pressed together so the outside wall of the male end is fused to the inside wall of the female end. Qualification of the fusion technician shall be demonstrated by evidence of socket fusion training within the past year on the equipment to be utilized on this project. [*Socket fusion is not widely used, and the specifier may decide to prohibit its use*]

D. Electrofusion: Electrofusion joining shall be done in accordance with the manufacturers recommended procedure; other sources include ASTM F1290, MAB-01 and MAB-02. Qualification of the fusion technician shall be demonstrated by evidence of electrofusion training within the past year on the equipment and pipe sizes to be utilized for this project.

E. Mechanical:

i. Mechanical connection of HDPE to auxiliary equipment such as valves, pumps, and fittings shall use flanges or mechanical joint adapters and other devices in conformance with the PPI Handbook of Polyethylene Pipe, Chapter 9 and AWWA Manual of Practice M55, Chapter 6. Mechanical connections shall be manufactured for HDPE pipe and approved by the connection manufacturer for use with polyethylene pipe.
Flanges and MJ adaptors should be double checked for butterfly valve clearance to allow full disc rotation and movement prior to installation in the trench. Uncontrolled tapering or hand-beveling in the field is not allowed.

ii. Mechanical connections on small pipe under 3” are available to connect HDPE pipe to other HDPE pipe, or a fittings, or to a transition to another material. The use of stab-fit style couplings is allowed, along with the use of metallic couplings of brass and other materials. All mechanical and compression fittings shall be recommended by the manufacturer for potable water use. Refer to fittings manufacturers and PPI Field Manual.

iii. Mechanical couplings that wrap around the pipe and act as saddles are made by several manufacturers specifically for HDPE pipe. All such saddles, tapping saddles, couplings and clamps shall be recommended by the manufacturer as being designed for use with HDPE pipe at the required pressure class (Section 1.4); all mechanical couplings shall be fully restrained either by themselves or by an alternate means.

F. Joint Recording - The critical parameters of each fusion joint, as required by the manufacturer and these specifications, shall be recorded by an electronic data logging device when available. All fusion joint data shall be included in the Fusion Technician’s joint report per ASTM F3124.

4.3 INSTALLATION

A. Open Trench Installation:

i. Pipe shall be installed per engineering drawings and ASTM D2487, ASTM D2774, ASTM D2321 and AWWA M55.

ii. When moveable trench bracing such as trench boxes, moveable sheeting, shoring or plates are used to support the sides of the trench, care shall be taken in placing and moving the boxes or supporting bracing to prevent movement of the pipe, or disturbance of the pipe bedding and the backfill. Trench boxes, moveable sheeting, shoring or plates shall not be allowed to extend below top of the pipe. As trench boxes, moveable sheeting, shoring or plates are moved, pipe bedding shall be placed to fill any voids created and the backfill shall be re-compacted to provide uniform side support for the pipe.

iii. Per AWWA M55, "ANSI/AWWA C906 PE pressure piping systems must be installed with fully restrained joints or with partially restrained joints AND external joint restraints. ANSI/AWWA C906 pressure piping systems that are joined by heat fusion, electrofusion, flanges, and MJ adaptors are fully [self-] restrained and do not require external joint restraints or thrust block joint anchors." Concrete embedded HDPE thrust anchors should be considered prior to connections to unrestrained pipes. Refer to AWWA M55 for design guidance.

B. Joining Methods for HDPE Pipe. The pipe and fittings shall be joined by butt fusion or electrofusion couplings, mechanical joint (MJ) adapters, or by flange connections in accordance with manufacturer's recommendations and as required in this document. Unless otherwise shown on Drawings and except for connections to existing utilities, all joints shall be fused.

i. Butt Fusion: The pipe shall be joined by heat fusion of the ends. Prior to fusion the pipe shall be clean and the ends shall be cut square. Butt-fusion joining is applicable to pipes that have the same nominal outside diameter and wall thickness, within one SDR. Field site butt-fusion system operators shall be trained in the use of the high quality butt-fusion equipment that secure and precisely align the pipe ends for the fusion process. Operators shall be trained by the pipe supplier or manufacturer of the fusing machine and be experienced in the operation of the equipment. Fusion quality shall be recorded, the recording of the information must be provided to the Owner. The Owner will review documents within 7 days and identify any fusion records that might indicate the need to replace an existing fused connection. The recorded fusion information must meet the standard requirements of TR-33, or the pipe manufacturer. All fusions failing to meet these requirements shall be removed and refused. Refer to ASTM F2620, ASTM F3124, ASTM F3183, ASTM F3190, PPI TR-33 and PPI TN-42.

ii. Electrofusion: ASTM F1290, ASTM F1055, MAB-01, MAB-02

iii. Mechanical Joint/Flange: A flange assembly consists of a metal back-up flange or bolt-ring and a polyethylene flange adapter. MJ assembly consists of a MJ adaptor with gland ring, gasket and bolt kit. Both MJ adapters and flange adapters are fused onto the plain end of the pipe main. Bolting guidance for MJ connections is provided in AWWA C600 and guidance for flanges is provided in PPI-TN38. Note that an HDPE flange adapter acts as both a flange and a gasket, and as such, no 'gasket' is required.

C. Water Mains and Accessories. HDPE connections to other pipe materials or valves and fire hydrants shall be made by mechanical joints, flanges or transition fittings. All connections to jointed gasketed pipe materials, valves or fire hydrants must be restrained and supported independently.

i. Restrained Mechanical Joints: Restrained mechanical joints shall be made using mechanical joint adapters. Refer to the manufacturer's instructions on the need for stiffeners when installing a mechanical joint.

ii. Flange: Flange connections shall be as described in Section 4.3.B.

D. Appurtenances: All appurtenances (tees, elbows, services, valves, air relief valves, fire hydrants, etc.), must be independently supported and shall not rely on the pipeline and its connections for this support. Excessive stresses may be encountered when appurtenances are inadequately supported.

E. Installation of Tracer Wire. The Contractor shall be required to install tracer wire along the entire section of pipeline and along all service connections as listed below. The tracer wire shall be installed simultaneously with the polyethylene piping system. Tracer wire shall be installed by the Contractor once backfill has been placed and compacted to at least 12 inches above the top of the pipe and not more than 18 inches above the top of the pipe. Tracer wire shall be properly spliced at each end connection and each service connection. Care should be taken to adequately wrap and protect wire at all splice locations. No bare tracer wire shall be accepted. Provide Magnesium alloy anode for cathodic protection that conforms to the requirements of ASTM B843. Install tracer wire per local and manufacturer's requirements.

i. Open Trench - Tracer wire shall be solid #12 AWG, (or stronger like #10) Copper Clad Steel, High Strength with minimum 450 lb. break load, with minimum 30 mil HDPE insulation thickness.

ii. Directional Drilling/Boring - Tracer wire shall be solid #12 (or stronger like #10) AWG, Copper Clad Steel or braided stainless steel (A316), Extra High Strength with minimum 1,150 lb. break load, with minimum 30 mil HDPE insulation thickness (applies to all wires).

iii. Pipe Bursting/Sliplining - Tracer wire shall be 7 x 7 (or stronger) Stranded Copper Clad Steel Extreme Strength with 4,700 lb. break load, or braided stainless steel (A316), with minimum 50 ml HDPE insulation thickness.

F. Backfill and Bedding:

1. Buried HDPE pipe and fittings shall be installed in accordance with ASTM D2321 or ASTM D2774 for pressure systems and AWWA M55.

2. Pipe embedment - Embedment material should be Class I, Class II, or Class III, materials as defined by ASTM D2321. The use of Class IV and Class V materials is not recommended. The particle size should not exceed the values shown in Table 3.

Table 3: HDPE Pipe Diameter Size vs. Embedment Particle Size

Pipe Diameter	Particle Size
≤ 4"	≤ ½"
6" and 8"	≤ ¾"
10" to 16"	≤ 1"
≥ 18"	≤ 1.5"

3. Pipe bedding shall be in conformance with ASTM D2321. Compaction rates should be as specified in ASTM D2321. Deviations shall be approved by the engineer.

4. Pipe haunches and backfill shall be as specified in ASTM D2321 with Class I, II, or III materials. Compaction shall be at a minimum of 85% Proctor *[Specifier to put in the percent compaction and other site specific and local requirements information].*

5. Contractor will install pipe in accordance with ASTM D2774, ANSI/ AWWA C901, ANSI/AWWA C906, AWWA M55 and the manufacturer's recommendations.

G. Cold (Field) Bending. Contractor shall not bend the pipe to fit a trench less than the radius shown in Table 4. The long-term minimum cold (field) bending radius shall be as follows:

Table 4: Minimum Long-Term Bending Radius per Pipe DR

Pipe DR	Minimum Cold Bending Radius (long-term)
≤ 9	20 x pipe OD
11 – 13.5	25 x pipe OD
17 – 21	27 x pipe OD
>21	30 x pipe OD
Fitting or Flange within bend	100 x pipe OD, for a distance 5x pipe OD, on each side of the fittings within the bend

H. Separation: Water Mains, Sewers, and Other Non-potable Fluid-carrying Pipelines shall be governed by the state or local responsible permitting agency.

I. Pull-In Installation

1. Per ASTM F1804 and/or www.HDPEapp.com, the contractor shall determine and document the maximum proposed pull-in length and pull-in force for the pressure class and pipe diameter to be pulled into an open trench. Pull-in lengths will not exceed the maximum lengths for the class and diameter pipe.

2. Prior to pulling the pipeline, contractor shall place rollers or other approved devices beneath the pipe to avoid unnecessary damage and to reduce pipe drag.

3. Per the manufacturer's recommendation, a commercially available load limiter (weak link) approved by the Engineer shall be used between the puller and the pipe. Appendix C.1 lists the Maximum Pull Force for PE4710 DIPS DR11/DR17 and for 12 hours; refer to HDPEapp for other conditions. Per ASTM F1804 and PPI PE Handbook, the maximum safe pull stress for PE4710 shall not exceed the values shown in Table 5**:**

Table 5: PE4710 (PE 445574) Safe Pull Tensile Stress

Load Duration	Safe Pull Stress at 73°F
½ hr. to 1 hr.	1400 psi
12 hrs.	1300 psi
24 hrs.	1250 psi

4. Trenchless installations:
   i. For HDD, refer to ASTM F1962, PPI TR-46, PPI PE Handbook (Chp 12) and www.PPIBoreAid.com
   ii. For sliplining, refer to ASTM F585, PPI PE Handbook (Chp 11) and www.HDPEapp.com
   iii. For pipe bursting, refer to PPI PE Handbook (Chp. 16)

J. Water Service Lines
   i. The minimum distance between service taps shall be 24 inches to maintain space for future work. All new services shall be shown accurately on the "as-built" drawings and tied to existing property lines. Tracer wire shall be installed along with all new HDPE services per Section 4.3 E.
   ii. The minimum tube size of a new and replacement water service shall be 1 inch PE4710 SDR 9. For other Special Sizes, refer to AWWA C901.
   iii. Water services shall be installed with a minimum cover as measured vertically from the top of the pipe to the top of pavement Where frost protection is not required, service shall be buried at least 18" deep. Where frost protection is required, refer to the local agency for burial depth.

4.4 TESTING.

A. Conduct hydrostatic leakage testing per ASTM F2164 and PPI TN-46. The test pressure shall be limited to a minimum of 1.5 x working pressure (and a maximum of 1.5 x PC- see Table 1) and shall not exceed the rating of the lowest component. In a fused HDPE water piping system, no leakage shall be present. If leakage is observed at a fusion joint, the test section shall be depressurized and allowed to 'relax' for at least eight hours before starting the next testing sequence. Leaks, failure or defective construction shall be promptly repaired by the Contractor at the Contractor's sole expense. The Contractor is responsible for the safety of their employees during the testing and repair.

4.5 CLEANING AND DISINFECTING

A. Cleaning and disinfecting of potable water systems shall be in accordance with AWWA C651 and AWWA M55 Chapter 10, and PPI Handbook of Polyethylene Pipe Chapter 2.
B. After installation and pressure testing, new water mains should be disinfected in accordance with procedures outlined in AWWA C651, using solutions of liquid disinfectants (not powders or tablets).
C. The liquid disinfection chemical solution should be limited to less than 12% active chlorine. The time-duration of the disinfection should not exceed 24 hours.
D. Upon verification of disinfection/purification, all service tubing, branch laterals, and distribution mains shall be thoroughly flushed with fresh potable water, and retested to verify the disinfectant chlorine level has been reduced to potable drinking water concentrations suitable for human consumption.

4.6 HYDRANT ASSEMBLIES AND FIRE SERVICES.

A. Hydrant Assemblies shall be installed and field tested according to the requirements of AWWA M17.

APPENDIX A: References

American Water Works Association, AWWA www.awwa.org

1. ANSI/AWWA C651 Standard for Disinfecting Water Mains
2. ANSI/AWWA C901 Polyethylene (PE) Pressure Pipe and Tubing, ¾ In. (19 mm) Through 3 In. (76 mm) for Water Service
3. ANSI/AWWA C906 Polyethylene (PE) Pressure Pipe and Fittings, 4 In. Through 65 In. (100 mm Through 1,650 mm), for Waterworks
4. AWWA M55 PE Pipe–Design and Installation

Plastics Pipe Institute, PPI www.plasticpipe.org

1. PPI Handbook of Polyethylene Pipe
2. PPI Polyethylene Piping Systems Field Manual for Municipal Water
3. PPI Position Paper on HDPE (PE4710) Distribution Potable Water Pipe Sizes and Pressure Classes
4. PPI Comments on Permeation of Water Pipes and on the AWWA-RF Report on Hydrocarbons
5. PPI TR-33 Generic Butt Fusion Joining Procedure for Polyethylene Gas Pipe
6. PPI TR-34 Disinfection of Newly Constructed Polyethylene Water Mains
7. PPI TR-41 Generic Saddle Fusion Joining Procedure for Polyethylene Gas Piping
8. PPI TN-13 General Guidelines for Butt, Saddle and Socket Fusion of Unlike Pipes and Fittings
9. PPI TN-38 Bolt Torque For Polyethylene Flanged Joints
10. PPI TN-44 Long Term Resistance of AWWA C906 Polyethylene (PE) Pipe to Potable Water Disinfectants
11. PPI TN-46 Guidance for Field Hydrostatic Testing of High Density Polyethylene Pressure Pipelines: Owner's Consideration, Planning, Procedures, and Checklists
12. PPI TN-47 Polyethylene Resin Testing Requirements to Support ASTM D2513 UV Exposure Limits of Polyethylene Compound
13. PPI TN-49 Recommendations for AWWA C901 Service Tubes in Potable Water Applications
14. PPI TN-54 General Guidelines for Squeezing Off Polyethylene Pipe in Water, Oil and Gas Applications
15. GTI/PPI PE4710 Mitered Elbow Finite Element Analysis
16. GTI/PPI PE4710 Mitered Tee Finite Element Analysis (Expected Spring 2018)

Municipal Advisory Board, MAB www.plasticpipe.org/municipal_pipe/advisory/

1. MAB-1 Generic Electrofusion Procedure for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe
2. MAB-2 Generic Electrofusion Procedure for Field Joining of 14 Inch to 30 Inch Polyethylene (PE) Pipe (Expected Dec. 1, 2017)
3. PPI TN-42 Recommended Minimum Training Guidelines for PE Pipe Butt Fusion Joining Operators for Municipal and Industrial Projects
4. PPI TR-46 Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe
5. Assessment and Calculation of BTEX Permeation Through HDPE Water Pipe, IUPUI, Purdue School of Engineering, July 2012
6. Fatigue of Plastic Water Pipe: A Technical Review with Recommendations for PE4710 Pipe Design Fatigue, JANA, May 2012
7. eTrenchless Software: PPI PACE, PPI BoreAid, HDPEapp

Manufacturers Standardization Society, MSS www.msshq.org

1. MSS SP-60 Connecting Flange Joints between Tapping Sleeves and Tapping Valves

NSF International www.nsf.org

1. NSF/ANSI 61 Drinking Water System Components–Health Effects

ASTM International www.astm.org

1. ASTM B843 Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
2. ASTM D2239 Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
3. ASTM D2321 Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

4. ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
5. ASTM D2683 Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
6. ASTM D2737 Standard Specification for Polyethylene (PE) Plastic Tubing
7. ASTM D2774 Standard Practice for Underground Installation of Thermoplastic Pressure Piping
8. ASTM D3261 Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
9. ASTM D3350 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
10. ASTM F585 Standard Guide for Insertion of Flexible Polyethylene Pipe Into Existing Sewer
11. ASTM F714 Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
12. ASTM F905 Standard Practice for Qualification of Polyethylene Saddle-Fused Joints
13. ASTM F1055 Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing
14. ASTM F1290 Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings
15. ASTM F1417 Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
16. ASTM F1563 Standard Specification for Tools to Squeeze-off Polyethylene (PE) Gas Pipe or Tubing
17. ASTM F1804 Standard Practice for Determining Allowable Tensile Loads for Polyethylene Gas Pipe During Pull-In Installation
18. ASTM F1962 Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit under Obstacles Including River Crossings
19. ASTM F2164 Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure
20. ASTM F2206 Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE) Plastic Pipe, Fittings, Sheet Stock, Plate Stock, or Block Stock
21. ASTM F2620 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
22. ASTM F2786, Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Gaseous Testing Media Under Pressure (Pneumatic Leak Testing)
23. ASTM F2880 Standard Specification for Lap-Joint Type Flange Adapters for Polyethylene Pressure Pipe in Nominal Pipe Sizes 3/4 in. to 65 in.
24. ASTM F3124 Standard Practice for Data Recording the Procedure used to Produce Heat Butt Fusion Joints in Plastic Piping Systems or Fittings
25. ASTM F3183 Standard Practice for Guided Side Bend Evaluation of Polyethylene Pipe Butt Fusion Joint
26. ASTM F3190 Standard Practice for Heat Fusion Equipment (HFE) Operator Qualification on Polyethylene (PE) and Polyamide (PA) Pipe and Fittings

APPENDIX B.1: ANSI/AWWA C906 PE4710 DIPS and IPS Pipe Sizes

Nominal Pipe Size, (inches)	Average Outside Diameter, (inches)	
NPS	**DIPS**	**IPS**
4	4.800	4.500
6	6.900	6.625
8	9.050	8.625
10	11.100	10.750
12	13.200	12.75
14	15.300	14.000
16	17.400	16.000
18	19.500	18.000
20	21.600	20.000
22	-	22.000
24	25.800	24.000
26	-	26.000
28	-	28.000
30	32.000	30.000
32	-	32.000
34	-	34.000
36	38.300	36.000
42	44.500	42.000
48	50.800	48.000
54	57.560	54.000
60	61.610	60.000
63	-	63.000
65	-	65.000

APPENDIX B.2: ANSI/AWWA C901 PE4710 CTS and IPS Pipe Sizes

Nominal Pipe Sizes, (inches)	Average Outside Diameter, (inches)	
NPS	**CTS**	**IPS**
¾	0.875	1.050
1	1.125	1.315
1 ¼	1.375	1.660
1 ½	1.625	1.900
2	2.125	2.375
3	-	3.5

APPENDIX C.1: Safe Pull Force for PE4710 DIPS @ 73ºF*

Nominal Pipe Size, (inches)	**Safe Pull Strength (lbs)**	
NPS (sample list)	**DIPS DR11**	**DIPS DR 17**
4	7,956	5,330
6	16,440	11,013
8	28,282	18,946
10	42,546	28,502
12	60,168	40,306
14	80,835	54,151
16	104,548	70,036
18	131,306	87,962
20	161,110	107,927
24	229,856	153,980
30	353,603	236,877

***Note:** Table based on 12 hours. Refer to HDPEAPP.com for other pipe sizes, DRs and conditions.