

SECTION 02XXX

POTABLE WATER COMPRESSIVE FIT LINING

PART 1 GENERAL

1.01 Scope of Work

The work specified in this section consists of furnishing and installing underground water mains using the compressive fit lining method of installation for pipes of various sizes. This work shall include all services, equipment, materials, and labor for the complete and proper installation, testing, and restoration of underground water mains and environmental protection and restoration.

The compressive fit lining method will repeat the method, outlined below for each section of pipe being installed. These processes may be performed in series or in parallel with other sections of pipe within the project; however each section will require these steps. The outline below of the process does not dictate the means and methods of the Contractor but provides an overview of the compressive fit lining process.

1. Deliver notice of service outage to each affected property Owner in advance of work
2. Chlorinate a length of product pipe that yields passing bacteriological test results for potable water per American Water Works Association (AWWA) and any applicable regulatory authority
3. Perform hydrostatic test of the product pipe section
4. Excavate an access pit at one end of the section down to pipe grade for placement of the any necessary equipment
5. Excavate an insertion pit at the opposite end of the section down to pipe grade for entry of the product pipe
6. Excavate any service or lateral connection pits
7. Isolate the section to be rehabilitated from the rest of the system to maintain pressure integrity of the system as well as preventing any backflow of chlorinated solution or non-potable water into the system
8. Excavate and remove hydrant tees, valve tees or other connections from the host pipe
9. Assess the condition of the inside of the existing pipe to determine the appropriate process for cleaning, removal of any obstructions and preparing the inside of the existing pipe
10. Clean the interior of the existing pipe using the appropriate cleaning devices, such as sprayers, scrapers, etc
11. Prove the interior size of the existing pipe by pulling through a foam pig which matches the OD of the pipe to be inserted as a compressive fit liner. If the foam pig doesn't clear any sections of the existing pipe, additional effort may be required to remove the obstruction
12. Assemble the rod string or cable as it is thrust through the host pipe from access pit to insertion pit

13. Attach product pipe to rod or cable end at insertion pit
14. Pull back and disassemble rod string or cable simultaneously while tooling and product pipe travels from insertion pit to access pit
15. Install service or lateral connections to the newly installed mains
16. Super-chlorinate main for 15 minutes to 300 ppm, de-chlorinate the residual chlorine when flushing and flush the newly installed main with potable water
17. Inspect for leaks at new connections
18. Perform final connection of the replaced section of pipe to the system

Items 12 – 14 can be substituted with another method to push or pull the replacement pipe into position. The contractor is responsible for the method of compressive fit liner insertion.

1.02 Contractor Qualifications

- A. Contractor (or Sub-Contractor) shall provide documented evidence of successful installation of pipe through the compressive fit lining method for work comparable in nature to the scope of work required by this project for a minimum of three years.
- B. Contractor (or Sub-Contractor) to have successfully self-performed at least (5) compressive fit lining projects to install product pipe of a similar nominal diameter and length to the proposed project within the past two years. Owner and Engineer shall have the sole authority to determine the adequacy of the representative projects.
- C. Contractor's (or Sub-Contractor's) project manager, superintendent, and machine operator assigned to compressive fit lining shall be experienced in work of this nature shall have successfully completed projects similar in nature and shall have successfully completed similar projects using compressive fit lining. Contractor (or Sub-Contractor) shall submit substantiating evidence of qualifications with the bid submittal documents.
- D. All compressive fit lining equipment operators shall be experienced in comparable compressive fit lining work, and shall have been fully trained in the use of the proposed equipment by an authorized representative of the equipment manufacturer(s) or their authorized training agents.
- E. All high density polyethylene (HDPE) fusion equipment operators shall be qualified to perform pipe joining using the means, methods and equipment employed by the Contractor. Fusion equipment operators must possess and be able to provide written validation (card or certificate) of current, formal training on all fusion equipment employed on the project, including training and proper use of the data logging device on the equipment. Qualification of the fusion technician shall be demonstrated by evidence of fusion training within the past two years on the equipment to be utilized on this project in accordance with ASTM F2620.

1.03 Referenced Standards

- A. American Water Works Association (AWWA) latest edition:
 - 1. AWWA M28 – Rehabilitation of Water Mains
 - 2. AWWA C651 – Disinfecting Water Mains
 - 3. AWWA C901 – Polyethylene Pressure Pipe and Tubing, ½ Inch Through 3 Inch for Water Service
 - 4. AWWA C906 – Polyethylene Pressure Pipe and Fittings, 4 Inch Through 63 Inch for Water Distribution and Transmission

- B. American Society for Testing and Materials (ASTM) latest edition:
 - 1. ASTM D638 – Tensile Method for Tensile Properties of Plastics
 - 2. ASTM D790 – Test Materials for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials
 - 3. ASTM D2122 – Standard Method of Determining Dimensions of Thermoplastics Pipe and Fittings
 - 4. ASTM D2239 – Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
 - 5. ASTM D2657 – Practice for Heat-Joining of Polyolefin Pipe and Fittings
 - 6. ASTM D2683 – Standard Specification for Socket Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
 - 7. ASTM D2774 – Standard Practice for Underground Installation of Thermoplastic Pressure Piping
 - 8. ASTM D2837 – Standard Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products
 - 9. ASTM D3035 – Polyethylene (PE) Plastic Pipe (DR-PE) Based on Controlled Outside Diameter
 - 10. ASTM D3261 – Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
 - 11. ASTM D3350 – Polyethylene Plastic Pipe and Fittings Material
 - 12. ASTM F3508 – Standard Guide for In-Situ Pipeline Renovation as Dual-Wall Composite Pipeline by Push/Pull Installation of Compressed-Fit Shape-Memory-Polymer Tubular (SMPT)
 - 13. ASTM F412 – Standard Terminology Relating to Plastic Piping Systems
 - 14. ASTM F714 – Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
 - 15. ASTM F905 – Standard Practice for Qualification of Polyethylene Saddle-Fused Joints
 - 16. ASTM F1055 – Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing
 - 17. ASTM F1056 – Standard Specification for Socket Fusion Tools for Use in Socket Fusion Joining Polyethylene Pipe or Tubing and Fittings

18. ASTM F1290 – Standard Practice for Electrofusion Joining Polyolefin Pipe and Fittings
19. ASTM F2164 – Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure
20. ASTM F2206 – Fabricated Fittings for Butt-Fused Polyethylene Plastic Pipe
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 F3124 – Standard Practice for Data Recording the Procedure used to Produce Heat Butt Fusion Joints
24. ASTM F3183 – Standard Practice for Guided Side Bend Evaluation of Polyethylene Pipe Butt Fusion Joint
25. ASTM F3190 – Standard Practice for Heat Fusion Equipment (HFE) Operator Qualifications on Polyethylene (PE) and Polyamide (PA) Pipe and Fittings

C. Plastics Pipe Institute (PPI) latest edition:

1. The Plastics Pipe Institute Handbook of Polyethylene Pipe – Chapter 11 Pipeline Rehabilitation by Sliplining with PE Pipe
2. PPI TR-3 – Policies and Procedures for Developing Hydrostatic Design Basis, Hydrostatic Design Stresses, Pressure Design Basis, Strength Design Basis, Minimum Required Strength Ratings, and Categorized Required Strength for Thermoplastic Piping Materials or Pipe
3. PPI TR-4 – PPI HSB Listing of Hydrostatic Design Basis, Hydrostatic Design Stresses, Pressure Design Basis, Strength Design Basis, Minimum Required Strength Ratings, and Categorized Required Strength for Thermoplastic Piping Materials or Pipe
4. PPI – TN-36 – General Guidelines for Connecting HDPE Potable Water Pressure Pipes to DI and PVC Piping Systems
5. PPI – TN-38 – Bolt Torque for Polyethylene Flanged Joints
6. PPI – TN-44 – Long Term Resistance of AWWA C906 Polyethylene (PE) Pipe to Potable Water Disinfectants
7. PPI – TN-45 – Mechanical Couplings for Joining Polyethylene Pipe
8. PPI – TN-46 – Guidance for Field Hydrostatic Testing of High Density Polyethylene Pressure Pipelines: Owner’s Considerations, Planning, Procedures, and Checklists
9. PPI – TN-49 – Recommendations for AWWA C901 Service Tubes in Potable Water Applications
10. PPI – TN-54 – General Guidelines for Squeezing Off Polyethylene Pipe in Water, Oil and Gas Applications

D. Plastics Pipe Institute (PPI) Municipal Advisory Board (MAB)

1. MAB Generic Electrofusion Procedure for Field Joining of 12 Inch and Smaller Polyethylene (PE) Pipe
2. MAB Generic Electrofusion Procedure for Field Joining of 14 Inch to 30 Inch Polyethylene (PE) Pipe
3. MAB Model Specifications for PE 4710 Buried Potable Water Service, Distribution and Transmission Pipes and Fittings
4. MAB Guidelines for PE 4710 Pipe Bursting of Potable Water Mains

1.04 Submittals

- A. Contractor shall submit personnel information detailing the names and resumes, including specific project experience, for the proposed project manager, superintendent, and compressive fit lining equipment operator proving that the experience meets the requirements detailed in this specification.
- B. Contractor shall submit personnel information, including specific project experience, for all proposed compressive fit lining equipment operators, including evidence of training in the use of the proposed equipment by an authorized representative of the equipment manufacturer or their qualified agent.
- C. Contractor to submit a plan to the Owner on a marked-up copy of the project documents showing the Contractor’s construction phasing and plans. Plan details shall include the following:
 1. Pit locations for access pit and insertion pit
 2. Pit locations for service and lateral connection pits
 3. Compressive fit lining schedule detailing which locations are to be replaced
 4. Lengths of each section to be compressive fit lined
 5. Isolation points to be used to seal the system during compressive fit lining
 6. Location of temporary services or pre-chlorination guidelines
 7. Staging area to be used for fusion and material storage
 8. Compressive fit lining equipment information to be used on the project such as tonnage and tooling
 9. Shoring system to be used with the compressive fit lining equipment and safe access to the excavations
 10. Risk management plan
- D. Submit pipe catalog information confirming that pipe, fittings, joints, and other materials conform to the requirements of the specifications.
- E. Submit pipe manufacturer’s most current calculations regarding tensile load limitations for trenchless installations.
- F. Provide information showing staging and pipe fusion areas, site access during work activities, pipe storage and handling and procedure for pipe joining.

- G. Contractor shall provide a plan to locate and protect all adjacent utilities and infrastructure.
- H. Submit traffic control plan for all entrance and exit pits.
- I. Provide as-built documentation. Contractor shall plot as-built conditions on the field drawings, including the location of pits and service connections at the completion of each production shift.
- J. Contractor to maintain all testing and quality control documentation and assurance procedures. Contractor to provide the following documents to the Owner:
 - 1. Quality control test reports
 - 2. Fusion reports for each weld as reported by the datalogger

1.05 Utility Locating

- A. The Contractor shall be responsible for following the procedures in this specification to identify, locate and verify the presence of existing utilities along the route of the proposed pipeline or work areas.
- B. Utility locating will be performed in three parts: identification, designating and verification.
 - 1. Utility Identification – Identify the presence of underground utilities through One Call service and visual observation of surface markers or other indicators such as manholes, valve boxes, fire hydrants, etc.
 - 2. Utility Designation – Marking the location of underground utilities with paint or flags based on utility owner information or third party locating equipment.
 - 3. Utility Verification – Verification of Utility Identification and Designation by excavation or other methods to determine the horizontal and vertical location of the underground utility. This also provides the size and material of the underground utility. Approved methods to accomplish this task include vacuum excavation, potholing, and test holes with traditional equipment (backhoes, etc.)
- C. The Contractor shall record the location (horizontal and vertical) of all known utilities, as defined within this specification, on the project documents. At a minimum, utilities shall be located by station and offset from the project baseline or with state plan coordinates. Vertical location can be based on depth from existing grade or elevation using the project vertical datum.
- D. The project documents showing all known existing utilities shall be submitted to the Owner’s Representative for review and to document, prior to construction, the known utilities within the project limits. The Owner’s Representative will have a

five (5) working day period to review and approve or comment on the utility locations.

- E. The approved project documents showing the existing utilities shall be the basis for changes to the contract as addressed within these specifications.
- F. Utilities located and documented as described above then subsequently damaged by the Contractor under this contract will have no basis for claims against the Owner for costs associated with repairs, delays, etc.
- G. Damage to existing underground utilities that were not identified by the procedures noted above will be the utility owner’s responsibility to repair or replace.

PART 2 PRODUCTS

2.01 Polyethylene Pipe, Fittings and Accessories

- A. Polyethylene pipe and fittings 4-65 inch diameter shall be in accordance with AWWA C906-15, material designation code of PE4710, all applicable ASTM standards and be listed on the PPI TR-4 HSB Listing of Hydrostatic Design Basis Listed Materials.
- B. Polyethylene pipe ½ -3 inch diameter for main line piping shall be polyethylene pipe (not tubing) in accordance with AWWA C901, material designation code of PE4710 all applicable ASTM standards and be listed on the PPI TR-4 HSB Listing of Hydrostatic Design Basis Listed Materials.
- C. Butt fusion fittings shall be made of HDPE material with a minimum material designation code of PE4710, all applicable ASTM standards and shall be listed in current versions of PPI TR-4. Molded and fabricated fittings shall have a pressure rating equal to the pipe unless otherwise specified on the project documents. All fittings shall meet the requirements of AWWA C901, C906 and all applicable ASTM standards. 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. Fabricated fittings shall be manufactured using a DataLogger to record fusion time, pressure and temperature, and shall be marked with a unique joint identifier that corresponds to the joint report. A graphic representation of the time and pressure data for all fusion joints made producing fittings shall be maintained for a minimum of five years as part of quality control and will be available upon request of owner. Qualification of the fusion technician shall be demonstrated by evidence of fusion training within the past two years on the equipment to be utilized on this project in accordance with ASTM F2620.
- D. Electrofusion fittings shall be made of HDPE material with a minimum material designation code of PE4710 and meet ASTM F1055. Electrofusion fittings shall

have a pressure rating equal to the pipe unless otherwise specified on the project documents. All electrofusion fittings shall be suitable for use as pressure conduits and have nominal burst values of four times the working pressure rating of the fitting. Marking of electrofusion fittings shall comply with the requirements of ASTM F1055. All electrofusion fittings shall be properly stored in compliance with the manufacturers recommendation.

- E. Saddle fusion could be used to fuse branch saddles, tapping tees and other HDPE fittings onto the wall of the main pipe. Saddle fusion shall be done in accordance with ASTM F2620 or PPI TR-41 or the fitting manufacturer's recommendations. 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 two years on the equipment to be utilized on this project in accordance with ASTM F3190.
- F. Socket fusion could be used to fuse branch saddles, tapping tees and other HDPE fittings onto the wall of the main pipe. Socket fusion shall be done in accordance with ASTM D2683 or the fitting manufacturer's recommendations. Socket 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 two years on the equipment to be utilized on this project in accordance with ASTM F3190. All equipment used for socket fusion should comply with ASTM F1056 and manufacturer's recommendations.
- G. Flanges and Mechanical Joint Adapters (MJ) shall have a minimum material designation code of PE4710 and meet all applicable AWWA and ASTM standards. Flanged and MJ adapters can be made to ASTM D3261 or machined in compliance with ASTM F2206. Flanges and MJ adapters shall have a pressure rating equal to the pipe unless otherwise specified on the project documents. Markings for molded or machined flange adapters or MJ adapters shall be per ASTM D3261. Fabricated (including machined) flange adapters shall be marked per ASTM F2206. Installation of all Flanged adapters shall follow the guidelines of the Plastics Pipe Institute TN-38.
- H. Glands, bolts, and gaskets shall be manufactured in accordance with AWWA C153. Bolts and nuts shall be grade 2 or higher.

2.02 Compressive Fit Pipe Liner

- A. The compressive fit pipe liner shall be installed in accordance with the guidelines of ASTM F3508.
- B. The compressive fit pipe liner to be installed on this project shall be a fully structural Class V and Class VI liner that complies with Table 1 Classification and Designation Specification for Shape Memory Polymer Composite Pipe as defined in ASTM F3508. The compressive fit pipe liner is required to comply with the

operating pressure requirements as defined by the project documents. Any HDPE liner less than a fully structural Class V liner will not be accepted.

- C. The compressive fit pipe liner shall use polyethylene pipe as required by Section 2.01, Polyethylene pipe, fittings and accessories.

2.03 Pipeline Identification

- A. All polyethylene pipe shall be marked in accordance with the standards to which it is manufactured.
- B. All polyethylene pipe shall be black, and shall contain a continuous colored stripe, 2 inches wide, located at no greater than 90 degree intervals around the pipe. Stripes shall be impregnated or molded into the pipe by the manufacturer. Application of the stripes after manufacture is not acceptable. Stripe color shall be:
 - 1. Potable Water Mains - blue stripes
 - 2. Reclaimed Water Mains - purple stripes
 - 3. Force Mains - green stripes
 - 4. Sanitary Sewer - green stripes
 - 5. Storm Sewer - no stripes required
- C. Grey or white polyethylene without stripes may be used for gravity or storm sewer applications as approved by the Owner or Engineer.
- D. All black polyethylene without stripes may be used for any installation in the interest of expediting delivery or reducing the cost of installation as approved by the Owner or Engineer.

2.04 Delivery, Storage and Handling of Materials

- A. Contractor is required to inspect materials delivered to the site for damage. All materials found during inspection or during the progress of work to have cracks, flaws, or other defects shall be rejected and removed from the job site without delay.

PART 3 EQUIPMENT

3.01 General

- A. The compressive fit lining equipment shall consist of a pulling unit that is capable of generating sufficient force to pull in the replacement pipe and trained and competent personnel to operate the system. All equipment shall be in good, safe operating condition with sufficient materials and spare parts on hand to maintain the system in good working order for the duration of the project. The contractor is responsible for the method of compressive fit lining insertion.

3.02 Other Equipment

- A. Pipe Rollers – pipe rollers, if used, shall be of sufficient size to fully support the weight of the pipe while being hydro-tested and during pull back operations. Sufficient number of rollers shall be used to prevent excess sagging of pipe.

3.03 Data Logger

- A. A data logger shall be used to record and document all butt fusion process. The data logger must be compatible and outfitted with an electronic data recording device. A digital report or printout for all fusion joints made that complies with, but is not limited to, ASTM F3124 must be delivered to the OWNER upon request and at the completion of the project. All hydraulic fusion must be recorded and able to produce a graphic representation of the time and pressure data. All manual fusion must be recorded with, but not limited to, Joint ID, Operator Name and ID, Pipe information, and Heater Plate Temperature. The recording unit shall be a DataLogger 7 as manufactured by McElroy Manufacturing, Inc, or newer model or approved equivalent.
- B. The Owner or Engineer may approve not implementing use of a DataLogger on small diameter pipe, 6 inches or less.

PART 4 EXECUTION

4.01 General

- A. Locate positions of access and insertion pits and lay out pipe assembly area. Lay out and assemble pipe in a manner that does not obstruct adjacent roads, and commercial or residential activities adjacent to construction areas.
- B. If an acceptable pre-determined outage period is not used, temporary water service connections shall be provided.
- C. The Contractor is to use a temporary bypass line comprised of large enough diameter polyethylene pipe or lay flat hose above ground to provide temporary bypass. The above ground polyethylene pipe or lay flat hose is to be protected by Contractor at all times.
- D. For temporary bypass, the Contractor shall provide flow diversion with pumps of adequate size and capacity to handle all flows generated during the pipe bursting process.

4.02 Pipe Joining

- A. High density polyethylene pipe shall be heat fused and pressure tested as per manufacturer's guidelines before installation in the existing pipe. During assembly and prior to pull in, pipe must be laid out in such a way as to minimize interference to pedestrian and vehicular traffic.
- B. Cuts or gouges that reduce the wall thickness by more than 10% are not acceptable and must be cut out, discarded and the pipe rejoined.
- C. Each butt fusion shall be recorded and logged by a datalogger affixed to the fusion machine. Joint data shall be submitted as part of the As-built documentation.
- D. Mechanical joining – in areas as to which auxiliary or final connections are to be made and the compressive fit pipe liner will not be pulled through the existing pipe, the polyethylene pipe and fittings may be joined together or to other materials by means of flanged connections or mechanical couplings designed for joining polyethylene pipe or for joining polyethylene pipe to another pipe material. Mechanical couplings shall be fully pressure rated and fully thrust restrained and installed in accordance with manufacturer's recommendations.
- E. After pulling pipe, clean exposed ends for installation of fittings.

4.03 Perform Inspection to Assess the Condition of the Existing Pipe

- A. Prior to insertion of the compressive fit pipe liner of the existing pipe, it shall be the contractors responsibility to remove any obstructions from the inside of the existing pipe that would preclude insertion of the compressive fit pipe liner.
- B. Inspection of the existing pipeline shall be performed by experienced personnel trained in locating breaks, obstacles and any external connections by closed circuit television or alternate inspection method. The interior of the pipeline shall be carefully inspected to determine the locations and extent of any failures or obstructions. The location of any conditions which may prevent proper installation of the compressive fit pipe liner into the existing pipeline shall be noted so the condition can be corrected. A video of the inspection shall be kept and submitted as part of the project documents.

4.04 Verify the Existing Pipe is Ready for Pipe Insertion

- A. The pipeline should be thoroughly cleaned using scrapes, wire brushes or other tools aimed at removing any internal corrosion, obstructions or other material that would preclude insertion of the compressive fit liner. All scale, sediment, corrosion or other loose material shall be removed prior to starting insertion of the compressive fit liner.
- B. The purpose of swabbing a new pipeline is to conserve water while thoroughly cleaning the pipeline of all foreign material, sand, gravel, construction debris and

other items not found in a properly cleaned system and to validate the ID of the existing pipe is appropriately sized to receive the compressive fit liner. Prior to pressure testing of a new pipeline swabbing shall be utilized as specified on the project documents for each project. A properly sized foam pig shall be pushed or pulled through the host pipe.

- C. New water mains greater than 12" ID (unless determined otherwise by the Owner) shall be hydraulically cleaned with a polypropylene swabbing device to remove dirt, sand and debris from main.
- D. If swabbing access and egress points are not provided in the design drawings, it will be the responsibility of the Contractor to provide temporary access and egress points for the cleaning, as required.
- E. At the receiver or exit point for the poly swab, the Contractor is responsible for creating a safe environment for collection of debris, water and the swab. Considerations shall be made for protecting surrounding personnel and property and safe retrieval of the swab.
- F. If there is any difficulty in pulling or pushing the foam pig through the host pipe, the contractor is to correct the obstruction.

4.05 Disinfection Testing (if Pre-chlorination is approved, see Section 4.05)

- A. Disinfection tests
 - 1. All water pipe and fittings shall be thoroughly disinfected prior to being placed in service. Disinfection shall follow the applicable provisions of the procedure established for the disinfection of water mains as set forth in AWWA C651. Bacteriological testing on the water main shall be scheduled, completed and sent for water analysis (lab testing.) The results of the lab testing shall be sent to the Owner. No pipeline shall be placed into service until it is properly disinfected and water analysis proves it is disinfected.
 - 2. Temporary blow-offs shall be installed for the purpose of cleaning the water main. Temporary blow-offs shall be removed and plugged after the main is cleared. The main shall be flushed prior to disinfection.
 - 3. The new water main shall be connected to the existing water main at one point only for flushing purposes. The new main **MUST** have a blow off on the end as required. After the new main is thoroughly flushed, the open end shall be sealed and restrained and the main shall be thoroughly disinfected.

4.06 Pressure and Leakage Testing

- A. Summary of Practice of Pressure and Leakage Testing
 - 1. The section of the piping to be tested is isolated from other parts of the

system and properly restrained in order to prevent failure of both the test section and the existing system connected to the test section. Isolated sections of the test section are vented to the atmosphere in order to ensure compressible gases do not remain within the hydraulic test section. The test section is filled with liquid, raised to the test pressure, and allowed to stabilize. The system is then inspected for leakage and the pressure is relieved. Any required repairs or replacements are then performed while the pipe is depressurized.

2. There is no leakage allowance, as properly made heat-fusion joints of HDPE do not leak. However, if any defects or leaks are revealed, they should be corrected and the pipeline retested after a minimum 24 hour recuperation period between tests. Total testing conducted on a section of pipeline shall not exceed eight hours within a 24 hour period.
3. An expansion allowance is allowed as HDPE will expand slightly due to elasticity and Poisson effects. The amount of make-up water (expansion allowance) will vary because expansion is not linear. This procedure compensates for expansion with an initial expansion phase followed by a testing phase as to which the test pressure is reduced suspending expansion. Expansion or contraction due to Poisson effects may disjoin other non-restrained joints, such as bell and spigot joints, so measures must be taken to fully restrain the test section.

B. Style of Testing

1. Conduct hydrostatic pressure testing of installed polyethylene pipe in accordance with ASTM F2164, Standard Field Leak Testing of Polyethylene Pipe and Crosslinked Polyethylene Piping Systems Using Hydrostatic Pressure.
2. It is not permitted to conduct pneumatic leak testing on HDPE in accordance with ASTM F2786, Standard Practice for Leak Testing of Polyethylene Piping Systems Using Gaseous Media Under Pressure (Pneumatic Leak Testing.)
3. Non-pressurized HDPE sewer mains may be pressure tested following ASTM F1417 Standard Practice for Installation Acceptance of Plastic Non-pressure Sewer Lines Using Low-Pressure Air.

C. Non-HDPE Components

1. Non-HDPE components, such as end caps, valves, etc., that are used to isolate the test section from other parts of the system in order to perform the test are required to be rated for pressures equal to or greater than the test pressure applied to the test section. These non-HDPE components must be properly restrained while conducting the pressure test.
2. Air release valves must be installed at the high points of the test section to allow for the release of any air or gases within the pipe prior to performing the required hydraulic pressure testing.

3. Pumping equipment used to pressurize the test section during the pressure testing should be of adequate capacity to fill, pressurize and test the section within the allotted time for the test.
4. A pressure monitoring gage is recommended to be connected to the test section at the lowest point to ensure the highest pressure is recorded within the test section. The combination of pump pressure and pressure at higher elevations will be recorded at the lowest point of the test section. Constant monitoring of the pressure during testing is required. A datalogger with a pressure recording transducer can be attached to the pressure gage to record pressure readings during the test. Additional gauges capturing the quantity of water used to fill prior to initial pressure testing and make up water during testing are required.

D. Safety

1. Take the necessary safety precautions to ensure the test is conducted safely during the entirety of the testing period. Persons operating near the test string should be familiar with pressure testing and understand the safety precautions necessary to perform the test safely.
2. The test section should be supervised at all times during pressure testing.
3. Failure of the HDPE pipe string may result in sudden, violent, uncontrolled and dangerous movement of the system piping, components or parts of the components.

E. Restraint against movement

1. Measures should be taken to ensure all parts and components of the pipe section under pressure testing should be restrained from movement either through the use of partial backfill or adequate above ground restraint methods.

F. Pre-test preparation and set-up

1. HDPE pipe materials are rated at temperatures of 73°F or less. Pressure testing at higher temperatures will require de-rating of the pipe and fittings in accordance with the manufacturer's recommendations.
2. Prior to testing, all heat fusion joints are to be completely cooled and allowed to cool beyond the required rough handling time.
3. The pipe string and components required to be tested should be flushed, pigged or otherwise cleaned to remove dirt and debris that may damage parts or components involved in the pressure testing.

G. Maximum test pressures

1. The maximum test pressure should not exceed the Owner's or Engineer's recommendations.

2. System operating pressures often refer to the actual pressure that the municipal water and wastewater pipeline systems experience during actual operation.
3. System design pressures often refer to the pressure rating of the HDPE pipeline that will be installed within the municipal water and wastewater pipeline system. HDPE pipe utilized in municipal water and wastewater systems often have higher rated design pressures than the operating pressures of the pipe systems they are installed within.
4. System operating and system design pressures are not always equal. It is necessary to establish if there is a difference between system operating and system design pressures. The Owner or Engineer will make a determination if the system operating pressure or system design pressures will be used to perform pressure and leakage tests on the pipe string.
5. The maximum test pressure for HDPE shall not exceed 1.5 times the system design pressure when lower pressure rated components or devices are not present. The maximum test pressure for HDPE shall not exceed the pressure rating of the lowest pressure rated components when they are present.

H. Test duration

1. The test duration required to pressurize, stabilize, hold test pressure and depressurize shall not exceed 8 hours. If retesting is necessary, the test section shall be depressurize for a minimum of 8 hours prior to restarting.
2. Prior to pressurizing, all components must be inspected to be in proper working conditions, all components of the test section shall be vented to atmosphere and all low pressure lines not part of the test section shall be disconnected from the test section.

I. Hydrostatic Test Procedure

1. The test section shall be filled slowly with liquid and all air is purged from the system. It is important to take steps to ensure all air is purged from the system. The flow velocity of liquid within the test section should not exceed the capacity of air to be purged from the system or the allowable design velocity of the pipe.
2. The test section should be allowed to come to temperature equilibrium between the pipe string and the fluid within the pipe.
3. When the test section is filled with fluid and purged with air, the pressure within the test section shall be gradually increased to the required test pressure. Make-up water should be allowed to fill the test section to maintain the required pressure due to expansion of the test section.
4. Once the pipe has stabilized, the pressure should be reduced 10 psi and the pressure monitored for 1 hour. The pressure should not be increased nor makeup water added to the test section during the observation period.
5. If not leakage occurs or if the internal pressure remains within 5% of the test phase pressure, the pressure test has passed.

J. Post test submittals

1. All records kept during pressure testing shall be provided to the Owner and Engineer.
2. Pressure test reports shall include the test liquid, backflow prevention devices, if used, weather conditions and ambient temperature at site of testing, test pressure, types of test gauges, location of test gauges including location distances and elevations, gauge calibration records, test pressures recorded, any adjustments made such as makeup water, etc, description of leaks or failures, date and time, and operator performing the pressure test.

4.07 Pre-chlorination of Product Pipe

Chlorination of pipes prior to compressive fit lining shall be carried out per ANSI/AWWA C651-99 Standard for Disinfecting Water Mains and in cooperation with the Owner. Any information here shall facilitate that method when performed on pipes not yet placed on grade. In general, the method includes the following:

- A. Disinfect all equipment, tools, end caps, pipe fittings or product that may contact pipe.
- B. Disinfection shall be carried out by immersing or rinsing items in a hypochlorus solution containing 1 to 5 percent chlorine measured by weight.
- C. Product pipe shall be fused into a string of sufficient length to complete the designated section or be coiled in a manner suitable for delivery on a pipe reel. Maximum allowable length is 800 feet.
- D. The surface upon which the product pipe rests during chlorination shall be relatively impervious and free from visible contamination. Coiled pipe must be laid horizontally to allow all air to be expelled.
- E. Swabbing, chlorination and testing of the inside diameter of the pipe shall be accomplished by the following:
 1. Swab being inserted at the lowest end of the pipe.
 2. Calcium Hypochlorite tablets or granules as described in Section 02510 shall be placed behind the swab
 3. Pressure tight end cap shall be mounted to the low end of the pipe either by fusing or mechanically assembled to the pipe.
 4. Potable water shall be introduced through this end cap at a controlled rate such that the swab is propelled at a velocity less than or equal to one foot per second. All air is to be dispelled from the pipe.
 5. Upon discharge of the swab from the elevated end of the pipe, the elevated end shall be capped with a pressure tight seal. This seal having a tapped access hole of size at least 1.25" NPT or incorporating the ability to leak (purge) air or water at will by adjustment of clamping bolts. Additional potable water should be added after capping to ensure that no air remains between the caps.

6. Pressure testing of the pipe section should be performed per this specification.
7. Chlorinated solution should be maintained in the pipe for a minimum of 24 hours prior to flushing when water temperature is above 41 °F (5°C), 48 hours when water temperature is 41°F (5°C) or less. Time for retention of the chlorinated solution shall not be significantly over designated holding time so as to prevent damage to the pipe or end caps.
8. After designated holding time, the pipe shall be drained, flushed and filled with potable water so as to expel the highly chlorinated solution. The spent chlorinated solution shall not be allowed to enter any water shed, a sanitary sewer or any other area where environmental damage may occur without neutralizing it in an industry acceptable manner. Flushing water shall be from a source known to be of drinking water standard.
9. Test samples shall be taken from each end of the pipe on consecutive days, 24 hours apart. Samples shall be tested by a state certified lab within 30 hours of being taken.
10. Failure of any sample to pass a bacteriological test should result in the related section of pipe being re-flushed and retested. Should any sample again fail, the section must be chlorinated before retest.
11. Time before re-connection of a passing pipe section shall be limited to 14 days from the last sampling. After this time the pipe must be retested to be acceptable for use.
12. Drain the section of pipe prior to compressive fit lining. The pipe shall be drained on the day of the compressive fit lining, and sealed after draining and for the compressive fit lining process.
13. Foam pigs should be designated by the manufacturer as suitable for potable water system use.

4.08 Compressive Fit Lining Operation

The compressive fit lining operation described within provides guidance on the basic process. It is to be understood that the need to make exceptions or additions to this process are common. These changes are made to accommodate nonstandard conditions. The contractor experience requirements make it reasonable to put the responsibility of devising these exceptions upon the Contractor.

A. Pit Location and Excavation

1. Access pit and insertion pit locations shall be placed such that excavations are minimized. This may be accomplished by placing either or both of these pits at the point of service or lateral connections, valve or hydrant location.
2. Initial compressive fit liner lengths shall be 500 feet (+/-) 50 feet in length for first two pulls to determine pipe friction and specific site conditions that may impact compressive fit lining lengths. After site specific factors are evaluated, longer compressive fit lining runs may be performed.

3. All pits shall be shored to ensure worker safety per OSHA or other local regulations.
 4. All pits shall be roped off and or covered when not active per OSHA or local regulations to ensure public safety.
 5. Traffic control shall be accommodated for by Contractor as per the Contract specifications. Safe traffic passage around pit excavations that are located in or adjacent to streets or highways shall meet Right-of-way Department requirements. Parking of related employee vehicles, trucks and auxiliary and equipment shall be such that congestion and traffic delays are minimized.
- B. Access Location and Shoring: compressive fit lining pull equipment requires preparation and planning for the access pit that they are to operate from, unless another method of push or pull is used by the contractor.
1. Forward face of the access pit or the surface that the machine bears against while pulling back, shall be shored in a safe manner. This shoring shall maintain perpendicular pulling machine alignment to the pipe during pullback. Any loss of perpendicular alignment during pull shall result in stopping of the pulling process and improvement of the forward face shoring.
 2. Rearward shoring shall be provided to react rod thrust forces during payout. While these forces are substantially lower than pullback forces, shoring must be used to stabilize the pulling machine so as to maintain perpendicular alignment of the machine during payout. The weight of the machine cannot be depended on to react thrust forces. Existing pipe at rear face of pit may only be utilized for rearward shoring if scheduled for replacement.
 3. Pipe face for Cast Iron, Ductile Iron, PVC or pre-stressed concrete cylinder pipe shall be cut off using a saw or similar device to produce a square face for the pulling machine forward face to bear against. Final separation of cast iron pipe with a wedge may provide a clean face. Existing pipe shall be removed in sufficient length to accommodate the pulling machine.
 4. The pulling machine must be positioned so as to have rod or cable centerline at approximate centerline of existing pipe.
 5. Rod box delivery and removal between temporary rod storage location and access pit must be accommodated for with appropriate lifting equipment and techniques. Additionally, movement and or placement of lifting machine must be included in traffic control plans.
- C. Rod or Cable Payout Operation
1. Rod or cable payout is the process of assembling a string of rods or solid cable and pushing them in a step wise manner from access pit, through the interior of the existing pipe to insertion pit.

2. Lifting of rod boxes into or out of the access pit shall be performed per OSHA or other applicable requirements with respect to equipment and method.
3. Threads shall be cleaned of foreign matter before assembly.
4. Counting of rods or cable during payout, or quantity of rods per box shall be monitored such that the equipment operator is aware of the distance between the pulling machine and the lead end of the rod string or cable.
5. Thrust force should be monitored by the operator. Should an unexpected sudden and significant increase in thrust force be experienced, the process shall be halted. The operator or Contractor shall review the results with the Owner to remedy in an attempt to determine if offsets, valves or other features or obstruction exist that may cause the rod string to leave the pipe.
 - a. Front end of the rod string should be located by distance from the access pit. Location should be painted and compared to as built documents.
 - b. Appropriate action should be taken to remedy the cause. This action may include an additional pit at the obstruction to determine the cause, and remove or accommodate for the obstruction. The Contractor shall follow the process provided in the approved Risk Management Plan.
6. Existing pipe in the insertion pit shall be cut or broken prior to arrival of the rod string. Sufficient length shall be removed so as to allow the pulling tooling to enter the existing pipe and bend the product within the allowable radius specified by the pipe manufacturer. The second end of the existing pipe in the insertion pit shall be positioned or worked so as not to damage the product pipe as it travels through the insertion pit.
7. Workmen shall not enter the insertion pit when the rod string or cable is nearing the pit. A workman shall be in visual or radio contact with the pulling machine operator so as to have the payout halted in a position that allows attachment of the pulling tooling. Pulling tooling style shall be chosen based on anticipated properties of existing pipe and existing pipe repairs.

D. Tooling and Attachment

1. The new polyethylene pipe shall be moved into position for attachment to the rod string or cable. Appropriate traffic or pedestrian control will be exercised along the path of the polyethylene pipe.
2. The lead and second rod or front of cable shall be painted orange or yellow so as to give notice to the pulling machine operator position of the pulling tooling.
3. Attachment of the pulling tooling to the rod or cable shall be through the use of removable pin joint allowing the tooling to pivot to the rod axis.
4. Attachment of the polyethylene pipe to the pulling tooling shall be with a swivel that permits rotation to relieve torsional (twist) stress on the polyethylene pipe.

5. The equipment used during the compressive fit process must be of the constant tension type.

E. Pullback Operation

1. The pulling machine operator will begin the pullback with the approval of the insertion pit observer. During the start of the pull, the pull speed must be reduced to allow the pull head to travel through the reduction die and into the host pipe. Progress will be made at a slow rate until the observer sees the pulling tooling has completely entered the existing pipe.
2. The pipe diameter of the HDPE will be temporarily reduced between 5% and 15% as the new pipe is pulled through the reduction die or other reduction device prior to entering the host pipe.
3. The reduction system will be uniform around the entire circumference to ensure no distortion occurs on the HDPE during pull in.
4. Should the forward shoring upon which the pulling machine bears yield sufficiently to bring the pulling machine out of square to the existing pipe, the shoring will be reworked.
5. Constant tension must be applied on the HDPE pipe string until the pull head reaches the receiving pit. The equipment used during the compressive fit process must be of the constant tension type.

F. HDPE Relaxation and Tooling Removal

1. Pulling machine operator shall note rod count or cable length and anticipate entry of painted rods into the access pit. As the pin joint connection nears the pulling machine forward face, the pull is to be halted. Load on the forward face is relieved by reversing the rod or cable direction slightly.
2. After the pull head reaches the receiving pit, the pulling force shall be removed. The contractor must use caution to pull the new HDPE a sufficient distance into the receiving pit so the pipe does not retract back into the host pipe.
3. The pulling machine shore plate is to be removed, allowing the tooling to enter a cage or the hull of the pulling machine. The tooling string will be disassembled and removed, in sections if necessary until the product pipe face has been pulled beyond the face of the access pit. The distance past the face of the access pit shall be at the discretion of the Contractor anticipating the length required for connection/fusing.
4. The HDPE pipe must be allowed to relax to allow full reversion for a period of 24 hours before tie in activities begin. The reversion period may lengthen or shorten depending on the characteristics of each pull, temperatures and other site specific conditions. The reversion process shall follow the natural reversion of HDPE and no methods shall be used to force the HDPE to revert to its natural form, using water, steam, heat, or other methods.

4.09 Reinstating Service and Lateral Connections

Upon completion of the compressive fit lining, certain tasks must be followed through in order to complete the overall process.

- A. Maintaining sanitary conditions within the product pipe after compressive fit lining must take high priority. Should any foreign matter, including ground water be allowed to enter the pipe interior, the condition of the pipe is no longer suitable for connection to the system. For this reason connections may not be made in standing water. Such water must be pumped or bailed prior to making the connection or unsealing the pipe. Areas under connections should be excavated below the pipe invert.
- B. Before joining a surface and before any special surface preparation to accommodate that joining, external surfaces should be clean and dry. Dust may be removed by wiping with clean, lint free cloth. Heavier deposits must be washed from the surface with soap and water and dried with a clean, lint free cloth.
- C. Incidental exposure of the interior of the pipe to any foreign matter shall require that one of the two following remedies be carried out:
 - 1. Complete chlorination per AWWA specifications for buried pipe and specifications.
 - 2. Localized contamination at the end of the pipe may be removed and the contaminated interior surface of the pipe wiped with a solution of 1 to 5% hypochlorite disinfecting solution.
- D. Service taps shall be of a type approved by the Engineer and must meet AWWA C906.
- E. Replacement or rehabilitation of service lines, if required, shall be according to contract.
- F. Post-chlorination: The section of main will be super-chlorinated to 300 ppm by inserting a foam pig at one end. The foam pig shall travel the entire length of the pipe section.
- G. Service Reinstatement: Prior to connection of the newly installed pipe, the section of pipe shall be fully flushed with the use of a de-chlorination unit and ascorbic acid to neutralize the residual chlorine. Following flushing, the newly installed section may be connected to the main at both ends and service reinstated.

4.010 Restoration

After completion of the compressive fit lining operation work areas, staging and storage areas are to be restored to equal or better condition than pre-construction condition.

END OF SECTION