SECTION 02336

HORIZONTAL DIRECTIONAL DRILLING

(WATER MAIN)

PART 1 GENERAL:

1.1 SUMMARY

A. This Section is intended to technically describe the nature of the materials, equipment and workmanship and include all work, materials, labor, equipment, and incidentals necessary to provide for the installation of water main pipe through horizontal directional drilling methods.

B. Related Requirements
1. Section 02660 – Water Main Systems
2. Section 02661 – Ductile Iron Water Main Pipe
3. Section 02662 – High Density Polyethylene Water Main Pipe

1.2 MEASUREMENT AND PAYMENT

A. **Water Main, _____, ____ inch, HDD……Foot**:
The Owner shall pay for **Water Main** installed by horizontal directional drilling of the material and diameter specified at the contract unit price per linear foot, measured in place along the centerline of pipe, which price shall be payment in full for furnishing the materials including specials and fittings, all necessary excavation, sheeting or bracing, draining, laying, jointing, bedding, testing, disinfecting, backfilling and compacting, disposal of surplus excavated materials, restoration and final cleanup, and all other work required for the construction of the water main. All labor, tools and material necessary to excavate for, lay, join, backfill, test, disinfect, and finish the water mains complete, shall be considered as part of the water main construction. Measurement of **Water Main** will be taken from end to end with no reductions for fittings and valves.

B. The cost associated with excavating, supporting, dewatering, using, and backfilling insertion and pulling shafts, access or exit pits, or other necessary excavations will not be paid separately, but shall be included in the unit price bid for **Water Main, _____, ____ inch, HDD**.

C. The costs associated with installing segments of water main pipe and fittings by open-cut methods, including necessary joint restraints, inline pipe restraint, stone bedding and initial backfill, thrust blocking, concrete anchors, and specified tracer wire will not be paid separately, but shall be included in the unit prices bid for **Water Main, _____, ____ inch, HDD**.

D. The following work items shall be included in the contract bid price per linear foot for **Water Main, _____, ____ inch, HDD**, unless otherwise described
1. Excavation, support/shoring, use, and backfilling of all access and exit pits
2. Dewatering Plan
3. Pilot Tunnel Boring
4. Removal and disposal of spoils

5. Monitoring, removal and disposal of drilling fluid including all costs associated with use of vacuum excavation equipment.
6. Traffic Control including efforts to maintain access to roads and driveways during all HDD operations
7. Exploratory locating and “potholing” of existing utilities
8. Settlement/Heaving Monitoring
9. Additional pipe work to connect to existing system
10. Hydrostatic Pressure Testing, Disinfection and Sampling
11. As-Built Survey
12. Clean-up
13. All additional items described herein as incidental to the work.

E. All appurtenances proposed as part of the project including but not limited to, physical connections to the existing system, gate valves, gate wells, hydrant assemblies, blow-offs, and air release valves will be paid for separately.

## 1.3 REFERENCES

A. Abbreviations and Acronyms
1. ANSI – American National Standards Institute (www.ansi.org)
2. ASTM – American Society for Testing and Materials
3. AWWA - American Water Works Association (www.awwa.org)
4. HDD – Horizontal Directional Drilling
5. NSF – National Sanitation Foundation

B. Definitions
1. Azimuth – the angle at which the downhole probe is projecting in the horizontal plane at a particular downhole survey point (magnetic north corresponds to zero degrees)
2. Product pipe – the piping to be permanently installed for the project.

C. Reference Standards
1. ASTM F1962 – Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings
2. PPI TR-46 Guidelines for Use of Mini-Horizontal Directional Drilling for Placement of High Density Polyethylene Pipe
3. AWWA M55 Manual of Water Supply Practices, PE Pipe – Design and Installation.
4. AWWA C651, “Disinfecting Water Mains”
5. NSF/ANSI Standard 61: Drinking Water System Components - Health Effects
6. All work shall comply with the reference standards unless specifically stated otherwise in the Specification.
7. References to documents and standards which are made part hereof shall be latest edition thereof.

## 1.4 PROJECT WORK PLAN

A. Prepare a Project Work Plan (PWP) in advance of the pre-construction meeting which clearly defines the HDD installation in conformance with the requirements of the Contract Documents. The PWP shall at minimum contain:
1. Working drawings including the location and dimension of all access pits.

2. Proposed shoring, support or temporary earth retention systems for access pits.
3. Installation sequencing and schedule.
4. Schedule of Submittals.
5. Traffic Control Plan
6. Project contact list and defined responsibilities.
7. Size, capacity and setup requirements of all equipment (including drill rig, thrust/pull-back and rotary torque capacity as well as the mud pump motor size)
8. Data logger compatible with HDD system used.
9. HDD guidance system type and information including the accuracy, range, and repeatability values for inclination, roll, and azimuth of the system.
10. Type of cutting tool head.
11. Method of monitoring and controlling line and grade.
12. Arrangement of equipment.
13. Location of product pipe joining areas and staging areas.
14. Dewatering plan and method
15. Method of removing spoils.
16. Water main material type, size, and class, including manufacturer recommended maximum allowable pulling force for the pipe and joints.
17. Method of joining water main pipe.
18. Method of installing tracer/detection wire.
19. Method of abandonment of pilot holes.
20. Carrier pipe end seals.
21. Preliminary Drilling Fluids Management Plan, refer to Article 1.6
22. Settlement/Heaving Monitoring Plan, refer to Article 1.6

B. Compensation for all work required for the preparation of the PWP shall be included in the cost of the project.

C. If during construction, the Contractor determines that modifications to the method and equipment as stated in the original submittal is necessary, then the Contractor shall submit a plan describing such modifications, including the reasons for the modifications, to the Owner for review and concurrence prior to making the modification.

1.5 SUBMITTALS

A. Comply with Specification Section 01300.

B. Refer to the related sections within the specifications for submittals required for the proposed product pipe to be installed via HDD.

C. Project Work Plan as detailed in Article 1.4.

D. Project Experience
1. Submit documentation showing three (3) years of guided boring experience with at least 15,000 feet of guided boring installation to include 6” to 24” diameter projects similar in the scope and value to the project specified in the contract documents.
2. Provide evidence of completion of at least five (5) projects of similar magnitude and soil and groundwater conditions.
3. Include the following information at a minimum;

a. Date, duration and location of the work,
b. Pipe information (i.e. length, diameter, depth of installation, pipe material, etc.),
c. Project owner information (i.e. name, address, telephone number, contact person, etc.), and,
d. Contents handled by the pipeline (i.e. water, wastewater, conduit, gas, etc.).

E. Personnel Experience
1. Submit a list of field supervisory personnel and their experience with guided boring operations.
a. Field supervisory personnel shall have a minimum of three (3) years' experience in the performance of the work and tasks as stated in the contract document.
b. At least one of the field supervisors listed must be at the site and be responsible for all work at all times when guided boring operations are in progress.
2. Include certifications for all operators, including the operator assigned to this job.
3. Certificate of training endorsed by the manufacturer of the HDD equipment.
4. Guided boring operations will be postponed until the resume(s) of the Contractor's field supervisory personal have been received, reviewed, and approved by the Owner.

F. Submit all drawings, catalog cuts and other descriptive data covering related items in the same system at the same time in order that their complete integrated applicability in the entire system may be adequately reviewed.

1.6 QUALITY ASSURANCE

A. Verify horizontal and vertical location of all known utility crossings along the proposed bore path in accordance with PA 174.

B. Drilling Fluids Management Plan
1. Provide a Preliminary Drilling Fluids Management Plan prior to the pre-construction meeting that generally describes the following;
a. Method of mixing fluid and water and storage requirements.
b. Method of slurry containment
c. Drilling fluid disposal
d. Drilling fluid spill prevention measures
2. Submit a Final Drilling Fluids Management Plan (DFMP) a minimum of two (2) weeks prior to starting HDD operations. The Final DFMP shall describe, at minimum, the following:
a. Type of drilling fluid to be used
b. Type of any proposed drill fluid additives
c. MSDS for all fluids and additives
d. Drilling fluid composition
e. Proposed ranges, test and test schedule for fluid density, viscosity and sand content of drilling fluid
f. Proposed primary and alternate fresh water sources
g. Method of mixing fluid and water and storage requirements.
h. Proposed drilling fluid pressures

3. Include a Drilling Fluid Disposal Plan as part of the Final DFMP. The Drilling Fluids Disposal Plan shall include, at minimum, the following:
    a. Method of slurry disposal and containment.
    b. Estimated volume of drilling fluid and spoil to be disposed of and the approximate timing of the schedule for the material to be disposed.
    c. Testing plan for the complete composition of the drilling waste.
    d. Methods of disposal and transporting off site of drilling fluids and spoils.
4. Include a Contingency Plan for Inadvertent Fluid Returns as part of the Final DFMP. The Contingency Plan shall include, at minimum, the following:
    a. Method of monitoring drill fluid pressures and description of the annular pressure tool used
    b. Methods of onsite monitoring for inadvertent returns (site walks, entry/exit pit fluid level monitoring, etc.)
    c. Range of fluid pressure changes indicative of a potential inadvertent fluid return to the surface.
    d. Communication method between monitoring personnel and the rig operator
    e. Decision points for communication method between Contractor, Owner's field representative and Engineer.
    f. Decision points and procedures for suspending drilling operations
    g. Containment methods
    h. Cleanup methods
    i. Downhole plugging agents and method and procedures of implementation
    j. List of emergency response equipment
    k. Corrective procedures to reestablish fluid circulation prior to initiating the restart of drilling operations

C. Settlement/Heaving Monitoring
1. Monitor potential heave or settlement at each shoulder point, each edge of pavement, the edge of each lane of pavement (or centerline for two lane roads), and otherwise at 50 foot intervals along the pipe centerline.
2. Perform baseline survey one day prior to initiating this operation at each required monitoring location.
    a. Perform daily follow-up surveys at the monitoring points established in the baseline survey until the HDD operations are complete.
    b. Record all survey readings to the nearest one-hundredth (0.01) of a foot.
3. Take digital photographs of the ground surface conditions prior to and after HDD operations.
4. Stop HDD operations immediately whenever monitored points indicate a vertical change in elevation of ½ inch or more, or any surface disruption is observed.
    a. Immediately report the amount of settlement to the Owner's resident project representative or permitting agencies inspector.

D. As-Built Survey
1. Provide a tabulation of coordinates referenced to the drilled entry point of the pilot hole drilling to accurately describe the location of the pilot hole.
2. Provide a log of the pullback pressures for each setup upon completion of the installation of each length of pipe.

1.7 SITE CONDITIONS

A. Drilling operations shall not interfere with, interrupt or endanger surface and activity upon the surface, and will be confined to the area of work as shown on the project drawings.

B. The Contractor shall carry out his operations in strict accordance with all OSHA and manufacturer's safety requirements. Particular attention is drawn to those safety requirements involving working with earth retention systems and entering confined spaces.

C. When rock stratum, boulders, underground obstructions, or other soil conditions that impede the progress of drilling operations are encountered, notify the Owner and Engineer immediately.
   1. The Owner, Contractor and Engineer shall review the situation and jointly determine the feasibility of continuing drilling operations, making adjustments or switching to an alternative construction method if necessary.
   2. When it is determined that it is impossible to continue drilling operations, the Contractor will be directed how to proceed by the Owner and the Engineer.

PART 2 PRODUCTS:

2.1 WATER MAIN PIPE

A. Material requirements for water main pipe of the material specified on the plans is included in the related Section for that type of pipe

2.2 EQUIPMENT

A. The directional boring equipment shall consist of, at minimum;
   1. A directional boring rig of sufficient capacity to perform the bore and pullback the pipe within the planned line and grade,
   2. A boring fluid mixing and delivery system of sufficient capacity to successfully complete the drilling operation,
   3. A guidance system to accurately guide boring operations, and
   4. Trained and competent personnel to operate the system.

B. Boring rig shall consist of a hydraulically powered system to rotate, push and pull the specified product pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill head.
   1. Anchor machine to withstand the pulling, pushing, and rotating pressure required to complete the drilling operation.
   2. Hydraulic Power System
      a. Self-contained with sufficient pressure to power the boring operation
      b. Free of Leaks
   3. Rig shall have a system to monitor and record maximum pull-back pressure during pull-back operations.
   4. Rig shall be grounded during boring and pull-back operations

C. The directional boring equipment must meet the minimum thrust/pullback rating, minimum rotary torque rating, and the minimum mud flow pumping capacity to facilitate installation of the product pipe per the contract drawings.

D. The guidance system must have the capability to locate and track continuously and accurately the drill head during the pilot bore, acceptable methods include;
1. Walkover
2. Wire Line
3. Magnetic Guidance System
4. Proven (non-experimental) gyroscopic probe
5. Owner approved equal

E. The guidance system shall have the ability to measure and provide information on the following;
1. Clock and pitch
2. Depth
3. Transmitter Temperature
4. Battery Status
5. Position (x,y)
6. Azimuth, where direct overhead readings (walkover) are not possible

F. The guidance system must have an independent means to ensure the accuracy of the installation.
1. Contractor will demonstrate a viable method to eliminate accumulated error due to inclinometer (pitch or accelerometer).
2. The guidance system shall be capable of generating a plot of the borehole survey for the purpose of an as-built drawing.

G. The proposed equipment set up requirements, including but not limited to proposed access and exit pit locations, are at the sole determination of the Contractor. Such information shall be submitted along with all other required information per the specifications.

2.3 DRILLING FLUID

A. No drilling fluid shall be used that does not comply with environmental regulations.

B. Drilling fluids shall be a mixture of clean water and bentonite clay.
1. The fluid shall be inert.
2. The fluid should remain in the tunnel to insure the stability of the tunnel, reduce drag on the pulled pipe, and provide backfill within the annulus of the pipe and tunnel.

2.4 DRILLING WATER

A. The Contractor shall provide clean water for the mixing of drill fluid.

B. The Contractor is responsible for locating a clean water source, and for transportation and storage of water.

C. The Contractor shall secure appropriate permissions from the entity having jurisdiction over the clean water source.

PART 3 EXECUTION:

3.1 GENERAL

A. Evaluate the atmosphere in and around the project site to determine the presence of toxic or flammable vapors or lack of oxygen prior to performing any access pit excavations or beginning drilling operations.

B. Perform HDD operations in a manner that will minimize the movement of the ground in front of, above, and surrounding the boring operation
   1. Minimize the subsidence of the surface above and in the vicinity of the boring.
   2. Support the ground in a manner to prevent loss of ground and keep the perimeter and face of the boring stable at all times, including during shutdown periods.

C. Dewatering
   1. Dewatering of pits and excavations must meet the general provision and specifications for watermain construction in effect per the Owner's requirements.
   2. The dewatering plan and method used by the Contractor, must be approved by the Owner, prior to commencing with the dewatering activity.
   3. When water is encountered, the Contractor must provide a dewatering system of sufficient capacity to remove water, keeping any excavations free of water until the backfill operation is in progress.
   4. Dewatering will be performed in a manner that removal of soil particles are held to a minimum.
      a. Soil Borings were performed and are provided per Specification Section 01900 Soil Conditions and Boring Logs.
      b. The groundwater level is subject to change, and the contractor shall be responsible for making his own determination of water levels that may exist during construction.
   5. All dewatering work, if necessary, shall be considered incidental to the unit bid prices listed in the project proposal.

3.2 PREPARATION

A. Excavate access pits at the locations and dimensions as necessary to horizontal directional drill the proposed watermain alignment as shown on the project drawings.
   1. Construct excavation in accordance with MIOSHA Construction Safety Standards for "Excavation, Trenching and Shoring".
   2. Install protection fencing or barriers adjacent to equipment and supplies to prohibit pedestrian access to the work site.
      a. Equipment shall not be used as fencing to protect access pits

B. Drilling procedures and equipment shall provide protection of workers particularly against electrical shock.
   1. As a minimum, grounding mats, grounded equipment, hot boots, hot gloves, safety glasses and hard hats shall be used by crewmembers.

C. Equip drilling equipment with an operational alarm system capable of detecting electrical current.

D. Rope off and cover all access pits when not active.

E. Size access pits to adequately contain the expected return of drilling fluids and spoils.

F. Removal of trees, landscaping, pavement or concrete will meet the general provisions and specifications for watermain construction per the Owner's requirements. However, any removals not noted on the drawings must be authorized by the Owner or Engineer.

G. The Contractor is responsible for protecting all existing utilities.
   1. The Contractor shall call Miss Dig a minimum of 3 working days before any work is to begin.
   2. Existing utilities within the path of the proposed horizontal directional bore, shall be "pot holed", to determine the depth.
   3. The costs of any "pot holing" will be borne by the Contractor and included in the unit bid price for installing the new watermain, unless a specific item is provided in the Proposal for exploratory digging and locating of utilities.

3.3 PRODUCTION

A. Abandonment of a bore or ream within the influence of the roadway is prohibited.

B. Minimize the period of shutdown between work shifts for boring, reaming or product pipe installation operations.
   1. 48 hours maximum

3.4 PILOT HOLE BORING

A. Maintain the entry angle and pilot hole during the boring process at a curvature that does not exceed the allowable bending radius of the product pipe.

B. Drill the pilot hole along the path shown on the plan and profile drawings to the following tolerances:
   1. Elevation: plus or minus 6 inches
   2. Alignment: plus or minus 6 inches
   3. Curve Radius: No curves will be accepted with a radius less than that shown on the drawings.

C. Alignment Adjustments and Restarts
   1. Follow the pipeline alignment as shown on the drawings, within the specifications stated.
      a. If adjustments are required, the Contractor shall notify the Engineer and Owner for approval prior to making the adjustments.
   2. In the event of difficulties at any time during boring operations requiring the complete withdrawal from the bore, the Contractor may be allowed to withdraw and abandon the bore and begin a second attempt at a location approved by the Owner and Engineer.
      a. The Contractor may excavate at the point of the difficulty and install the product pipe by trench method, at no additional cost to the Owner, per the general provisions and specification for construction.
   3. The number of access pits shall be kept to a minimum.

a. The equipment must be capable of boring and installing the watermain in a continuous run without intermediate pits, of a minimum distance of 600 feet unless otherwise authorized by the Engineer.
b. The maximum length of any bore shall not exceed 1200 feet unless otherwise authorized by the Engineer.

4. Plot the actual horizontal and vertical alignment of the pilot bore hole at each edge of pavement and at intervals not exceeding 20 feet. Update this plot as the pilot bore is advanced.

D. Pilot Hole Final Location

1. Submit a tabulation of the coordinates of the pilot bore, exit and entry points and a drawing of the drilled profile upon completion of the pilot hole.
2. Product pipe shall not be installed until the Contractor has confirmed that the pilot hole is within the tolerances stated in this specification.
3. In the event the drilled profile fails to meet these specifications, the Owner reserves the right to reject the drilling attempt
   a. Upon notice of rejection, the Contractor shall abandon the hole and submit a proposed profile for an additional drill attempt.
   b. If the proposed profile is approved, the Contractor shall complete a new pilot bore
   c. No additional compensation shall be paid for failed attempts.

## 3.5 INSTALLING PRODUCT PIPE

A. After the pilot hole is completed, install a swivel to the reamer to minimize torsional stress imposed on the pull section and commence pullback operations.

1. Should pre-reaming of the tunnel be necessary, it shall be performed at the option of the Contractor, and at no additional cost to the Owner.

B. The reaming diameter shall not exceed 1.4 times the diameter of the product pipe being installed.

C. For product pipe diameters' greater than 20-inch, an intermediate pre-reaming is required before pulling the pipe into place.

D. The product pipe being pulled into the tunnel shall be protected and supported so that it moves freely and is not damaged by stones and debris on the ground during installation.

1. Utilize pipe rollers, skates or other protective devices to prevent damage to the pipe, eliminate ground drag, reduce pulling force and reduce the stress on the pipe and joints.

E. Assemble required piping in a manner that does not obstruct adjacent roadways or public activities.

F. Tracer wire is required for all non-metallic pipe installations.

1. Refer to product pipe specification for tracer wire requirements.

G. Drill path alignment shall be as straight as possible to minimize the frictional resistance during pullback and maximize the length of the pipe that can be installed during a single pull.

H. Pullback forces shall not exceed the allowable pulling forces for the product pipe.

I. Provide for sufficient length of product pipe to extend past the termination point to allow for product pipe reversion, if applicable, and connections to adjacent pipe sections or gate valves.

J. Pulled pipes will be allowed a minimum of 72 hours of stabilization prior to making tie-ins, unless otherwise indicated.
   1. This duration may be reduced or extended at the Owner's discretion based on the pipe material being installed or the length of the bore.

K. Temporarily seal pulled pipe ends with a cap until the connection is made permanent.

L. Do not remove the drilling fluid in the annular region outside of the pipe after completion of the pipeline installation. The drilling fluid is to remain in place to provide support for the pipe and the neighboring soil.

3.6 DRILLING FLUID

A. Utilize drilling fluid during drilling and back reaming operations.
   1. Endeavor to maintain full annular circulation of drilling fluids.
   2. Minimize drilling fluid returns at locations other than the entry and exit points.

B. Dispose and Contain excess drilling fluids in accordance with the submitted Drilling Fluid Disposal Plan.
   1. Store excess drilling fluid within a lined pit or containment pond, or trailer-mounted portable tank, as approved by the Owner, until removed from site.

C. Dispose of excess drilling fluid and spoils in accordance with the submitted Drilling Fluid Disposal Plan.
   1. Drilling fluid waste must be tested prior to disposal
   2. Transport all excess drilling fluid and spoils to the disposal site at no additional cost to the Owner.
   3. Transport excess drilling fluid and spoils in a manner that prevents accidental spillage onto roadways.
   4. Do not discharge excess drilling fluid and spoils into streets, manholes, sanitary or storm drain systems, other drainage systems, or waterways.

D. Drilling fluid returns caused by fracturing, formations, or any other means at locations other than the entry and exit points shall be minimized.
   1. Immediately clean up and dispose of any drilling fluid and spoils from return areas.

E. The Contractor shall provide mobile spoils removal equipment capable of quickly removing spoils from entry and exit pits and from return areas.
   1. Equipment must be present during all HDD operations to fulfill the disposal requirements previously described.

3.7 OBSTRUCTIONS DURING CONSTRUCTION

A. Notify the Owner and Engineer immediately upon encountering an obstruction that stops the forward progress of the drilling operation.

B. Review the situation with the Owner and Engineer and determine the feasibility of continuing drilling operations or switching to an alternative construction method.

3.8 FIELD QUALITY CONTROL

A. Provide and maintain instrumentation which will accurately perform the following functions:
   1. Locate the pilot bore entry point.
   2. Record coordinates of the pilot bore hole referenced to the drilled entry point.
   3. Monitor and measure drilling fluid flow discharge rate and pressure.
   4. Monitor and measure pullback pressure.

B. Provide the Owner and Engineer access to the instrumentation at all times.

3.9 HYDROSTATIC PRESSURE TESTING

A. Conduct hydrostatic pressure testing in accordance with the specification for the material specified on the plans.

3.10 DISINFECTION

A. Disinfect water main in accordance with ANSI/AWWA C651 and as described in Section 02660.

B. Unless otherwise indicated, Contractor to coordinate bacteriological samples with a certified laboratory and the Owner.

3.11 FINISH

A. The finished product pipe shall be as commercially practicable from visual defects such as foreign inclusions, scratches, gouges, pinholes and delamination.

B. For non-metallic product pipe, check the tracer wire connectivity.

C. Restore to existing condition all excavations required for proper installation and inspection of the product pipe. Site restoration for the HDD operation is considered included in the cost of construction unless otherwise indicated under separate pay items listed in the Proposal.

3.12 NON-CONFORMING WORK

A. Non-conforming work is any work outside of the acceptable tolerances for the item of work identified within these specifications that is considered to affect the performance and/or future maintenance of the new product pipe.

B. Product pipe pulled in place outside of the horizontal and vertical alignment tolerances will be reviewed by the Owner for impact to the functionality of the product pipe and the associated network of piping.
   1. Decision on the impact of the finished product by Owner is final and non-negotiable.
   2. If the final position of the product pipe is determined to have a negative impact of the associated network of piping, the Contractor will either;

a. Bore a parallel product pipe of the same material, size, class, etc. to within the specified tolerances, if feasible, and cap and abandon the previously bored product pipe, or
b. Install system improvements, as determined by the Owner, to balance the negative impacts to the system the installed product pipe would provide.

C. The finished product pipe shall be continuous over the entire length of the pipe section and be as free as commercially practicable from visual defects such as foreign inclusions, scratches, gouges, pinholes and delamination.
1. Any visual defects shall be repaired at the Installation Contractor's expense in a manner mutually agreed upon by the Owner and the Installation Contractor.
2. Damage to the product pipe in excess of the manufacturer's established tolerances are not acceptable and will require removal and replacement or abandonment of the product pipe in accordance with Article 3.10.B.2.a.

END OF SECTION