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USACE / NAVFAC / AFCESA / NASA **UFGS-33 05 23.19 (April 2006)**

Preparing Activity: NAVFAC **Replacing without change UFGS-02441 (August 2004)**

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2013
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DIVISION 33 - UTILITIES

SECTION 33 05 23.19

TRENCHLESS EXCAVATION USING MICROTUNNELING

04/06

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SECTION 33 05 23.19

TRENCHLESS EXCAVATION USING MICROTUNNELING
04/06

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NOTE: This guide specification covers the requirements for work related to the installation of utility systems (i.e., electrical power, communications, water, gas, oil, petroleum products, steam, sewage, drainage, irrigation, and similar facilities) utilizing the microtunneling trenchless excavation methods.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable items(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).
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NOTE: Microtunneling Horizontal Earth Boring is a process characterized as highly sophisticated, laser guided, remote controlled system providing the capability of continuous accurate monitoring and control of alignment and grade.

1. Microtunneling is ideally suited for placing a 450 to 1800 mm 18 to 72 inch casing pipe for containing utility lines. Distances between manholes can exceed 300 m 1000 linear feet. It is ideally suited for utility lines that must be buried in rock, sand, clay and contaminated soils in depths ranging from 1.8 to 30 m 6 to 100 feet below grade. Varied soil conditions can be dealt with a single

cutting head and dewatering is greatly reduced. There are many manufacturers of equipment that can perform the work described in this specification.

2. Permanent pipe casing can be used as the carrier pipe or a separate pipe may be placed inside the casing. The designer has the option of selecting the casing pipe however it may limit the number of possible bidders.

3. Cathodic protection for steel pipes should be considered where the anticipated degree of corrosion is so great that coating systems, including polyethylene encasement, are not adequate to protect the piping for the desired life of the system.

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NOTE: Project Drawings:

1. The following information should be shown on the project drawings:

a. Plan and location of all new pipelines, including size of pipe casing and carrier pipe.

b. Location and profiles of soil sampling and bore holes.

c. Location, size, and type of service of existing connecting, intersecting, and adjacent pipelines and other utilities.

d. Paved areas and railroads which pass over new pipelines.

e. Profile, where necessary to show unusual conditions.

f. Manhole and lateral piping bedding conditions.

g. Details for the connection of the pipe casing to manholes and infiltration control.

h. Location of surrounding structures and sensitivity to settlement, pile foundations, and subsurface structures that could be affected by the project.

i. Show traffic plans for work near roadways and possible equipment and spoils storage areas. Spoil storage and removal requires a large area for dewatering and must be strictly controlled in Section 01 57 19.00 20 TEMPORARY ENVIRONMENTAL CONTROLS. Refer the other sections for specific removal and disposal of hazardous materials. Spoil storage locations and construction need to consider possible runoff into wetlands, streams, or storm drains.

j. Maximum working pressure of the system.

k. Class or thickness of pipe, including material identification, and limits for same where class or thickness will differ along length of pipeline.

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PART 1 GENERAL

1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a RID outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 13A	(2010) Specification for Drilling-Fluid Materials
API Spec 5L	(2007; Errata 2009; Addenda 1 2009; Addenda 2 2010; Addendum 2 2011; Addendum 3 2011; 44th Ed) Specification for Line Pipe

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2008; Errata 2010) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C111/A21.11	(2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C150/A21.50	(2008) Thickness Design of Ductile-Iron Pipe

AWWA C151/A21.51	(2009) Ductile-Iron Pipe, Centrifugally Cast, for Water
AWWA C200	(2012) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C203	(2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M	(2012; Errata 2011) Structural Welding Code - Steel
AWS D1.5M/D1.5	(2010) Bridge Welding Code

ASTM INTERNATIONAL (ASTM)

ASTM A139/A139M	(2004; R 2010) Standard Specification for Electric-Fusion (ARC)-Welded Steel Pipe (NPS 4 and over)
ASTM A53/A53M	(2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
ASTM A716	(2008) Standard Specification for Ductile Iron Culvert Pipe
ASTM A746	(2009) Standard Specification for Ductile Iron Gravity Sewer Pipe
ASTM C1208/C1208M	(2011) Standard Specification for Vitrified Clay Pipe and Joints for Use in Microtunneling, Sliplining, Pipe Bursting and Tunnels
ASTM C301	(2004; R 2009) Vitrified Clay Pipe
ASTM C443	(2011) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM C443M	(2012) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric)
ASTM C497	(2005) Concrete Pipe, Manhole Sections, or Tile
ASTM C497M	(2005) Concrete Pipe, Manhole Sections, or Tile (Metric)
ASTM C700	(2011) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated
ASTM C76	(2012) Standard Specification for

	Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
ASTM C76M	(2011) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric)
ASTM D1248	(2012) Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable
ASTM D3212	(2007) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3262	(2011) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe
ASTM D4161	(2001; R 2010) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
ASTM F477	(2010) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F794	(2003; R 2009) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter

[1.2 RELATED REQUIREMENTS

Section 01 57 19.00 20 SAFETY REQUIREMENTS, applies to this section with additions and modifications specified herein. Section 23 03 00.00 20 BASIC MECHANICAL MATERIALS AND METHODS, applies to this section with additions and modifications specified herein.

]1.3 DESIGN REQUIREMENTS

1.3.1 Pipe Casing

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NOTE: Design Requirements:

1. External loads shall include earth loads, truck loads, seismic loads, construction loads (i.e., sheetpile insertion/extraction at manholes and pipe ramming/jacking forces) and impact in the design stage of the project; also hydrostatic and buoyancy forces.

2. It is recommended that the following site information should be provided (at a minimum):

a. Grain size analysis of soil particles

b. Unconfined compressive strength of soils

c. Dry density

d. Cohesion

e. Shear strength

f. Plasticity of fill material

g. Classification of fill material

h. Rock type and color

i. Permeability

j. Moisture content

k. Water table depth

l. Nature of pollutants

m. Grain size

n. Core recovery TCR SCR

o. Fracture index

p. Standard penetration N value

q. Friction angle

r. Where possible, soil boring information should be provided at not more than 60 m 200 ft intervals outside the bore of the tunnel and at manhole locations.

3. Use equivalent pipe design for the project conditions (using the applicable criteria for each pipe material) for each different pipe material.

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NOTE: Provide only those pipe sizes and materials applicable to the project requirements.
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NOTE: Choose one of the following options.
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[Provide pipe casing indicated as [_____] mm inch of [polyvinyl chloride (PVC) plastic] [clay tile] [concrete] [steel] or [_____] pipe. Provide utility line accessories, [valves], [connections], and [manholes] as specified and where indicated. Submit design calculations of pipe casing.]

****
NOTE: Where the casing will not serve as the actual carrier or utility line, specify the appropriate

carrier pipe, joints and connections in other specification Sections 33 11 00 WATER DISTRIBUTION and 02630, "Storm Drainage."

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1.4 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list to reflect only the submittals required for the project.

The Guide Specification technical editors have designated those items that require Government approval, due to their complexity or criticality, with a "G". Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For submittals requiring Government approval on Army projects, a code of up to three characters within the submittal tags may be used following the "G" designation to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.][for information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Microtunneling Boring Machine equipment to be used

SD-03 Product Data

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NOTE: Use other specifications to require submittals for the actual carrier pipe unless the pipe casing is going to act as the carrier pipe.

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Piping casing, joints, fittings, valves, and couplings

Bentonite

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on [and rubber-gasketed bell-and-spigot] joints. Include information concerning gaskets with submittal for joints and couplings.

SD-05 Design Data

****
NOTE: Suggested Submittals:

1. The following material should be submitted for review by the designer:

a. Manufacturer's literature describing in detail the microtunneling system to be used. Detailed descriptions of projects on which this system has been successfully used, giving total pipe length, project duration, and number of restarts.

b. Method of spoil removal.

c. Anticipated jacking loads.

d. Method(s) of controlling groundwater at shafts and by the microtunneling boring machine.

e. Shaft dimensions, locations, surfaced construction, profile, depth, method of excavation, shoring bracing, and thrust block design.

f. Verification that the pipe complies with the specification.
****

Design calculations of pipe casing

SD-07 Certificates

Piping casing piping, fittings, joints, valves, and coupling

Shop-applied linings

Certificates shall attest that tests set forth in each applicable referenced publication have been performed, whether specified in that publication to be mandatory or otherwise and that production control tests have been performed at the intervals or frequency specified in the publication. Other tests shall have been performed within 3 years of the date of submittal or certificates on the same type, class, grade, and size of material as is being provided for the project.

SD-08 Manufacturer's Instructions

Installation procedures for pipe casing

1.5 DELIVERY, STORAGE, AND HANDLING

Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials on site in enclosures or under protective covering. Store [plastic piping, jointing materials and] rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, [and] [valves] free of dirt and debris.

1.5.1 Handling

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NOTE: Delete coatings not allowed for the project. AWWA M11 in the chapter on protective coatings contains information on the relative merits of cement mortar and coal-tar enamel coatings. See Forward to AWWA C210 for information on coal-tar epoxy coating.

****

Handle pipe, fittings, valves, hydrants, and other accessories in a manner to ensure delivery to the excavation in sound undamaged condition. Take special care to avoid injury to coatings and linings on pipe and fittings; make satisfactory repairs if coatings or linings are damaged. Carry, do not drag pipe to the excavation. [Store plastic piping, jointing materials and] [rubber gaskets that are not to be installed immediately, under cover out of direct sunlight.] [Handle steel pipe with [coal-tar enamel] [coal-tar epoxy] coating in accordance with the provisions for handling coal-tar enamel coated pipe in AWWA C203.]

1.6 QUALITY ASSURANCE

1.6.1 Design Calculations of Pipe Casing

Submit design calculations of pipe casing demonstrating that the pipe casing selected has been designed to support the maximum anticipated earth loads and superimposed live loads, both static and dynamic, which may be imposed on the pipe casing.

PART 2 PRODUCTS

2.1 PIPING CASING MATERIALS

****

NOTE: Allowable Materials:

1. The project specification should allow all carrier piping materials for the utility lines which are suitable for the project, each to be permitted as a Contractor's option. The structural support contribution of the casing piping and annulus grout may be considered when specifying the thickness of the utility piping. The casing may also greatly reduce infiltration of ground water.

2. Pipe materials which are known to be unsuitable for particular local conditions, (i.e., corrosion, deterioration, etc.) should not be permitted for the project for either the casing or the utility

piping. However, consider use of more effective protective coatings, etc., where economically feasible. Consider the protective nature of the pipe casing and annulus grout with regards to exterior attack. [Cathodic protection of the casing may also be desirable.]

3. Utility piping material and size should be specified in their own appropriate sections of the specification.

4. Several methods of installing pipe casings are available to the Contractor. Different tunneling machines have different means of installing the casing. Many of the machines allow the pipe casing to be used as the jacking shield and are left in place after the tunneling head has reached the receiving pit. Other machines use a temporary jacking shield that is replaced with a lighter casing. The final casing material does not need to be as strong because it does not need to jack the cutting head. Fiberglass casing can be an appropriate alternative for these methods. The Contractor should have the option of selecting an appropriate alternative for the casing based on his tunneling method and the design requirements of the utility lines.

5. The annulus grout (e.g., the grout the fills the void between the casing and the utility line(s) is traditionally a lightweight grout that is designed to merely stabilize the utility line(s). The utility lines are usually temporarily supported on wooden shims to position them inside the casing prior to grouting.

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2.1.1 Piping Casing

2.1.1.1 Ductile-Iron Piping

****

NOTE: Insert the necessary Pressure/Thickness Class to meet project conditions, as determined from AWWA C151/A21.51.

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a. Pipe and Fittings: Pipe, [except flanged pipe,] AWWA C151/A21.51 [Pressure Class [_____]] [Thickness Class [_____]]. The outside diameter of ductile iron microtunneling pipe shall be in accordance with AWWA C150/A21.50.

(1) Deflection: The maximum allowable deflection shall not exceed three percent of the outside diameter of the pipe barrel for pipe manufactured with a rigid lining and/or rigid coating nor five percent for pipe manufactured with a flexible lining and/or flexible coating.

(2) Linings: [Cement mortar shall be in accordance with latest

version of AWWA C104/A21.4] [Polyethylene lining shall be virgin polyethylene complying with ASTM D1248 compounded with an inert filler and with sufficient carbon black to resist ultraviolet rays.]

(3) End Squareness: The ends of the pipe shall be perpendicular to the longitudinal axis of the pipe with a maximum deviation of not more than 6 mm 0.25 inches.

(4) Hydrostatic Test: Each pipe section shall be subject to a hydrostatic test of not less then 3447 kPa 500 psi as per the requirements of AWWA C151/A21.51. Non-standard joint lengths shall be cut only from full length pipe having satisfactorily passed the required 3447 kPa 500 psi hydrostatic test.

(5) Material Properties: The following are representative minimum values for the physical properties of ductile iron for use as microtunneling pipe for pressure or gravity service.

(a) Tensile strength: Minimum 420 MPa 60,000 psi

(b) Tensile yield strength: Minimum 300 MPa 42,000 psi

(c) Compressive strength: The compressive yield strength of ductile iron is 10 to 20 percent higher than the tensile yield strength. The ultimate strength in compression is not normally determined for ductile metals, though apparent strength in tests may be several times the tensile strength value.

(d) Elongation: Minimum 10 percent.

(e) Modulus of Elasticity: 165,500 MPa 24,000,000 psi (tension or compression).

(f) Poisson's ratio: 0.28

(6) Spigot End Outside Diameter: The Spigot end outside diameter must be within the following ranges: [75 to 300 mm, plus 1.5 mm] [350 to 600 mm, plus 1.3 mm] [750 to 1200, plus 2.0 mm] [1350 to 1600 mm, plus 1.0 mm] [3 to 12 inches, plus 0.06 inches] [14 to 24 inches, plus 0.05 inches] [30 to 48 inches, plus 0.08 inches] [54 to 64 inches, plus 0.04 inches].

b. Joints and Jointing Material:

****
NOTE: Do not locate flanged, grooved, and shouldered joints on buried pipelines unless they are in valve pits or chambers.
****

Joints: Pressure and gravity microtunneling pipe shall have either an integral-bell push-on or rubber gasket coupled joint meeting the following criteria:

(1) Integral-bell push-on joint microtunneling pile shall consist of a rubber-gasket joint manufactured to conform with AWWA C111/A21.11 and the dimensions shown in AWWA C151/A21.51. The exterior of the pipe shall be coated with a durable cement-mortar or concrete

coating applied in such a manner as to provide a uniform outside diameter.

(2) Cement-mortar or concrete strength, reinforcement and method of placement shall be in accordance with manufacturer's recommendations. [Durable Coatings of other types may be substituted provided they maintain a uniform outside diameter and they are approved by the designer.] Rubber gasket coupled microtunneling joint shall be manufactured so as to provide a joint which has the same nominal outside diameter as the pipe barrel.

2.1.1.2 Polyvinyl Chloride Pipe (PVC)

ASTM F794. ASTM D3212 for gasketed joint systems. ASTM F477 for gasket materials.

****
NOTE: Polyvinyl Chloride Pipe (PVC): PVC pipe may be an ideal conveyance system for sewage and storm water, and for the construction of culverts installed and constructed by microtunneling methods. These pipes require microtunneling systems that generate low compressive loads on the pipe.
****

2.1.1.3 Reinforced Concrete Pipe

****
NOTE: This section covers reinforced concrete pipe intended for use as conveyance systems of sewage and storm water, and for the construction of culverts and industrial casings installed and constructed by jacking methods.
****

a. Pipe: Pipe, [[_____] mm inch inside diameter,] class [_____], wall [_____], nominal length [_____] and concrete strength [_____] MPa psi in accordance with ASTM C76M ASTM C76.

****
NOTE: Reinforced Concrete Pipe:

1. Nominal dimensions: Typical nominal dimensions for reinforced concrete pipe are detailed in ASTM standards [ASTM C76M ASTM C76, ASTM C655M ASTM C655, ASTM C822]. Pipe meeting these requirements is generally acceptable for jacking. The permissible variation allowed with respect to these and other dimensions should be in accordance with the variations listed in the section.

2. Pipe lengths: Concrete pipe manufactured for jacking operations should be typically manufactured in lengths of 2.25 to 2.4 m 7.5 to 8 feet. This is primarily a function of the size of the jacking equipment and the excavation. Lengths vary in any given geographical area.

3. Joint: Historical field data has shown that concrete pipe joint for jacking applications is commonly of two types, all concrete or concrete and steel. Factors influencing the selection of one of these joint types, or other alternative joints, include:

a. Magnitude of the anticipated jacking forces

b. Joint deflection characteristics

c. Joint shear strength required during the jacking operation

d. Specific site design parameters.

4. Joint description: Two primary types of joints are used:

a. Joint formed entirely of concrete that may utilize a rubber gasket or mastic to provide the seal. Rubber gaskets should be used where water tightness is needed. A compressive bearing strip is required between the faces of the adjoining pipes.

b. Joint includes an assembly of steel bands or steel bell ends with spigot rings and rubber gaskets. This type of joint also requires a compressive bearing strip.

5. Joint selection: Historical performance has shown that in instances of straight alignment under relatively low jacking forces, both types of joints can be used. Curved alignments and high jacking pressures may require the use of the second type of joint.

6. Axial load capacity: A factor of safety of at least 2.22 should be used for pipes installed by jacking methods. The axial load capacity should be based on the ultimate strength of the concrete and it assumes that the load is uniformly distributed over the bearing surface. Eccentric or concentrated load combinations on the pipe surface should be evaluated for effective surface contact area and reduction in the factor of safety.

****

(1) Internal Diameter: The internal diameter of [300 to 600 12 to 24 inches pipe shall not vary by more than plus6 mm plus1/4 inch from the design diameter]. [686 mm 27 inch and larger pipe shall not vary from the design diameter by more than plusone percent or plus10 mm plus3/8 inch, whichever is less].

(2) Wall Thickness: At any location along the length of the pipe, or at any point around its circumference, the wall thickness shall not vary by more than plusfive percent.

(3) End Squareness: Each pipe end shall lie within two planes

perpendicular to the longitudinal center line of the pipe, spaced at 10 mm 3/8 inches apart. The tongue or spigot end shall be square within 5 mm 3/16 inches and the groove or bell end of the pipe shall be square within 5 mm 3/16 inches.

(4) Hydrostatic Test: Each pipe section shall be subject to a hydrostatic test of not less than [69 kPa 10 psi for straight] [90 kPa 13 psi for deflected] alignment as per the requirements of section 10 of ASTM C443M ASTM C443 and section 8 of ASTM C497M ASTM C497. Non-standard joint lengths shall be cut only from full length pipe having satisfactory passed the required [_____] kPa psi hydrostatic test.

(5) Roundness: The outside diameter of the pipe shall not vary from a true circle by more than 1.0 percent. The out-of-round dimensions shall be one half the difference between the maximum and minimum outer diameter of the pipe at any one location along the barrel.

(6) Length of Pipe: Finished pipe length shall not deviate from design length by more than plus3 mm per 300 mm plus1/8 inch per foot with a maximum variation of plus13 mm 1/2 inchin any length of pipe.

(7) Length of two opposite sides: Variations in laying length of two opposite sides of the pipe shall not be more than [6 mm 1/4 inch for all sizes through 600 mm 24 inches internal diameter] [3 mm per 300 mm 1/8 inch per foot for all sizes larger than 600 mm 24 inchesin internal diameter], with a maximum of 10 mm 3/8 inches in any length of pipe.

b. Joints and Jointing Material:

Joints: Joint shall [be formed entirely of concrete and as detailed in the contract drawings, [may] [shall] utilize a rubber gasket or mastic to provide the seal]. [Incorporate an assembly of [steel bands] [or] [steel bell ends] and spigot rings and rubber gaskets in accordance with contract drawings].

2.1.1.4 Steel Pipe

****
NOTE: This section covers steel pipe used as an encasement for other carrier pipes or it may also serve as the carrier pipe for water, gas, sanitary sewer or other utility products.
****

a. Pipe: Steel pipe shall be in conformance with [ASTM A139/A139M, Grade B with a minimum yield strength of 242 MPa 35,000 psi] [AWWA C200] [API Spec 5L Grade B] [ASTM A53/A53M] [ASTM A716] [ASTM A746]. Steel pipe shall be welded, seamless, square cut with even lengths [and shall comply of Articles 4.2, 4.3, and 4.4 of the API Spec 5L].

(1) Roundness: The difference between the major and minor outside diameters shall not exceed [one percent] of the specified nominal outside diameter of 6 mm 0.25 inch whichever is less. [For pipe exceeding 1200 mm 48 inches in diameter, a maximum deviation of 13 mm 1/2 inch shall be permitted provided the circumference

tolerance is maintained within 6 mm 1/4 inch.]

(2) Circumference: The outside circumference shall be within plus1 percent of the nominal circumference or within plus13 mm plus0.50 inches, whichever is less.

(3) Straightness: The maximum allowable straightness deviation in any 3 m 10 foot length shall be 3 mm 1/8 inch. [For lengths over 3 m 10 feet, the maximum deviation of the entire length may be computed by the following formula, but not to exceed 10 mm 3/8 inch in any 12 m 40 foot length:

(1/8) times (total length in meters divided by 0.125 equals Maximum Deviation in mm) (1/8) times (total length in feet) divided by 10 equals Maximum Deviation in inches)]

(4) Pipe ends: The end of the pipe shall be perpendicular to the longitudinal axis of the pipe and within 2 mm per meter 1/16 inches per foot of diameter, with a maximum allowable deviation of 6 mm 1/4 inch measured with a square and straightedge across the end of the pipe.

b. Joints: The connection of adjacent pieces of microtunneling steel pipe may be accomplished by [field buttwelding,] [internal weld sleeves,] [integral press fit connectors,] as long as loading and installation design criteria are met.

2.1.1.5 Fiberglass Pipe

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NOTE: This section covers centrifugally cast fiberglass pipe for installation be pipe jacking and microtunneling for use in sanitary sewer, storm drain, wastewater collection and industrial effluent applications.
****

a. Pipe: Fiberglass pipe shall meet the requirements of ASTM D3262, Type 1, Liner 2, Grade 3. The method of the manufacture shall be centrifugal casting resulting in a controlled outside diameter. Minimum wall thickness shall be plus38 mm plus1.5 inches.

(1) Roundness: The pipes shall be round within 0.1 percent of the outside diameter.

(2) Pipe lengths: Lengths tolerance shall be plus6 mm plus1/4 inches per length of pipe.

(3) End squareness: Pipe ends shall be perpendicular to the pipe axis within a tolerance of plus2 mm plus1/16 inch.

(4) Straightness: Pipes shall be straight to within plus2 mm plus 1/16 inch over 3 m 10 feet.

(5) Jacking strength The average ultimate axial compressive strength shall be 83 MPa 12,000 psi minimum. The jacking capacity shall be based on the structural wall (end area) under the gasket groove (reduced cross-section). The allowable jacking capacity shall be determined by applying a 2.5 safety factor.

b. Joints: The pipes shall be connected by gasket-sealed bell-spigot joints. The gasket material shall meet requirements of ASTM F477. The joint shall meet the requirements of ASTM D4161and shall be leak-free under the following conditions:

(1) External pressures up to 2 bars 200 kPa 29 psi from bentonite injection, slurry system operation or groundwater head.

(2) Internal air testing up to 35 kPa 5 psi.

(3) Gaps between the pipe ends up to two percent of the diameter (maximum of 25 mm one inch).

[c. The liner shall consist of a minimum thickness of 1.2 mm 0.04 inch of reinforced polyester resin. The outside pipe coating shall have a minimum thickness of one mm 0.03 inches and shall consist of thermosetting polyester resin and sand.]

2.1.1.6 Vitrified Clay Pipe

ASTM C700.

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NOTE: This section covers the criteria for the manufacture, quality assurance testing, inspection, installation, and field acceptance testing of vitrified clay pipe to be used in jacking, sliplining, and in tunnels for the conveyance of sewage, industrial wastes, and storm water.

****

a. Pipe: Vitrified clay pipe shall be manufactured from fire clay, shale, surface clay, or a combination that can meet three edge bearing strength for nominal diameters of: [100 mm 2980] [150 mm 2980] [200 mm 3278] [250 mm 3576] [300 mm 3874] [375 mm 4321] [450 mm 4917] [525 mm 5736] [600 mm 6556] [675 mm 7003] [750 mm 7450] [900 mm 8940] [1050 mm 10430] kg/m [4 inches 2000] [6 inches 2000] [8 inches 2200] [10 inches 2400] [12 inches 2600] [15 inches 2900] [18 inches 3300] [21 inches 3850] [24 inches 440] [27 inches 4700] [30 inches 5000] [36 inches 6000] [42 inches 7000] lb/linear foot.

(1) Acid Resistance: The pipe shall be resistant to acid in accordance with test methods specified in ASTM C301.

(2) Compressive Strength: Pipe materials shall have a minimum compressive strength of 48 MPa 7,000 psi.

(3) Dimensional tolerances: The outside diameter shall not vary from a true circle by more than 2 percent of its nominal diameter. The out-of-round dimension is the difference between the maximum and minimum diameters measured at any one location along the barrel and must be limited to less than. Pipe shall not deviate from straight by more than 1.3 mm per 300 mm 0.05 inches per linear foot when maximum offset is measured from the concave side of the pipe.

(4) End squareness: The space formed by a pipe end shall not deviate by more than 0.13 mm per 25 mm 0.005 inches per inch of outside diameter.

b. Joints: Joints shall be capable of supporting a shear load of 8755 N/m 50 pounds per inch of nominal diameter uniformly applied over an arc of not less than 2.09 rad 120 degreesand along a distance of 300 mm 12 inches adjacent to the joint. Apply an internal 3 m 10 foot head 30 kPa 4.3 psi of water pressure for a period of one our. Joints shall fully comply with ASTM C1208/C1208M.

2.2 CONCRETE

Concrete shall be 25 MPa 3000 psi and conform with Section 03 30 00 CAST-IN-PLACE CONCRETE of this specification.

2.3 BENTONITE

Bentonite shall conform with API Spec 13A and have the capacity of mixing with water to form a stable and homogeneous suspension.

2.4 BACKFILL

Reuse excavated sand for backfill that conforms with Section 31 00 00 EXCAVATION.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Access Shafts

a. Construction methods required to provide access shafts for microtunneling shall be subject to approval of the Contracting Officer. Acceptable construction methods may include the use of interlocked steel sheetpiling or precast circular concrete segments lowered in place during excavation.

b. Final dimensions of access shafts selected by the Contractor shall be modified as required following installation of pipe casings to the size and shape of acceptable manhole designs shown on the Contract Drawings [to permit installation of conveyance piping.]

c. Shafts shall be of a size commensurate with safe working practices and located as shown on plans. With the approval of the Contracting officer, the Contractor may relocate shafts to better suit the capabilities of the microtunneling method proposed. Where no locations are given, the Contractor shall determine such locations with the approval of the Contracting Officer.

d. Shaft locations shall, where possible, be kept clear of road intersections and within a single traffic lane, in order to minimize disruption to the flow of traffic. Support equipment, spoil piles, and materials shall also be located such as to minimize disruption to traffic and are subject to the approval of the Contracting Officer.

e. The Contractor shall properly support all excavations and prevent movement of the soil, pavement, utilities or structures outside of the excavation. The Contractor shall furnish, place and maintain sheeting, bracing, and lining required to support the sides and floor of all pits and to provide adequate protection of the work, personnel, and the general public. Design loads on the sides of the jacking and receiving

pit walls are dependent on the construction method and flexibility of the wall systems.

f. Construct a starter shaft to accommodate the installation of pipe casings, slurry shield and piping jacking device. Install thrust block as required and consolidate the ground (grout) where the casings exit the shaft.

g. Construct a receiver shaft to accommodate the installation of pipe casings and the slurry shield. Consolidate the ground (grout) where the casings enter the shaft.

h. The Contractor shall furnish, install, and maintain equipment to keep the jacking shaft free of excess water. The Contractor shall also provide surface protection during the period of construction to ensure that surface runoff does not enter driving shaft(s). Groundwater dewatering shall comply with the approved dewatering plan and shall not affect surrounding soils or structures beyond the tolerances stated in paragraph entitled "Settlement, Alignment and Tolerances."

i. Provide security fence around all access shaft areas and provide shaft cover(s) when the shaft area is not in use.

j. Design of the jacking and receiving pit supports should also take into account the loading from shield or pipe jacking where appropriate, as well as special provisions and reinforcement around the breakout location. The base of the pits shall be designed to withstand uplift forces from the full design head of water, unless approved dewatering or other ground modification methods are employed.

k. Where a thrust block is required to transfer jacking loads into the soil, it shall be properly designed and constructed by the Contractor. The backstop shall be normal (square) with the proposed pipe alignment and shall be designed to withstand the maximum jacking pressure to be used with a factor of safety of at least 2.0. It shall also be designed to minimize excessive deflections in such a manner as to avoid disturbance of adjacent structures or utilities or excessive ground movement. If a concrete thrust block or treated soil zone is utilized to transfer jacking loads into the soil, the tunnel boring is not to be jacked until the concrete or other materials have attained the required strength.

l. Pit Backfill and Compaction: Upon completion of the pipe drive and approval of the installed pipeline by the Contracting Officer, remove all equipment, debris, and unacceptable materials from the pits and commence backfilling operation. Backfilling, compaction and pavement repairs shall be completed in accordance with Section 31 00 00 EXCAVATION.

[m. If tremie concrete sealing slabs are placed within the earth support system to prevent groundwater inflow when access shafts are dewatered, the sealing slabs shall be of sufficient thickness to provide a factor of safety equal to 1.2 against hydrostatic uplift in order to prevent bottom blowout when the excavation is completely dewatered.]

3.2 INSTALLATION

3.2.1 Installation of Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such a manner that will not be displaced during construction operations.

3.2.2 Connections to Existing Lines

Make connections to existing lines after Government approval is obtained and with a minimum interruption of service on the existing line. Make connections to existing lines under pressure [in accordance with the recommended procedures of the manufacturer of the pipe being tapped] [as indicated].

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NOTE: Microtunneling Information

The minimum depth of cover over the pipe being installed using the microtunneling process is normally 1.8 m 6 feet or 1.5 times the outer diameter of the pipe being installed, whichever is the greater. Microtunneling work is executed so as to minimize settlement or heave. The overcut of the tunneling machine or method shall be determined by the need to satisfy settlement or heave tolerances. Overcut should not exceed 25 mm one inch on the radius of the pipe. The annular space created by the overcut usually can be filled with the lubricating material that is used to reduce the friction drag of the soil on the pipe (i.e., bentonite slurry).

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3.2.3 Settlement, Alignment and Tolerances

a. Settlement or heave of ground surface along centerline of microtunneling alignments during and after installation of pipe casings shall not exceed [_____] mm inches.

b. No more than [_____] mm inch lateral and [_____] mm inch vertical deviation shall be permitted in the position of the completed jacked pipe casings. [Water shall be free draining between any two points at the pipe invert. No reverse grades will be allowed.]

[c. Overcut shall not exceed 25 mm one inch on the radius of the pipe being installed. The annular space created by the overcut [may] [must] be filled with the lubrication material that is used to reduce soil friction drag on the pipe.]

3.2.4 Microtunneling

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NOTE: Select one of the following options. The first option restricts the Contractor to using an unmanned tunneling machine while the second option also permits the Contractor to use tunneling shields.

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[a. The microtunneling boring machine shall be an unmanned mechanical type earth pressure counter-balanced bentonite slurry shield system. The machine shall be laser guided and monitored continuously, with a closed circuit television system. The machine shall be capable of fully supporting the face both during excavation and during shutdown and shall have the capability, of positively measuring the earth pressure at the face. Excavation face pressure shall be maintained at all times between the measured active earth pressure and 50 percent of the computed passive earth pressure. Fluid pressure applied at the face to stabilize the excavation shall be maintained at a level slightly in excess of normal hydrostatic pressure and shall be monitored continuously. The machine shall be operated so as to prevent either surface heave or loss of ground during tunneling and shall be steerable and capable of controlling the advance of the heading to maintain line and grade within the tolerances specified in paragraph entitled "Settlement, Alignment and Tolerances." The machine shall be capable of handling and removing materials of high water content from the machine head.

b. Each pipe casing section shall be jacked forward as the excavation progresses in such a way to provide complete and adequate, ground support at all times. A bentonite slurry (driller's mud) shall be applied to the external surface of the pipe to reduce skin friction. A jacking frame shall be provided for developing a uniform distribution of jacking forces around the periphery of the pipe. A plywood spacer shall be placed on the outer shoulder of the pipe casing joint. The thrust reaction backstop shall be properly designed and constructed.

c. The backstop shall be normal (square) with the proposed pipe casing alignment and shall be designed to support the maximum obtainable jacking pressure with a safety factor at least 2.0.

d. The jacking system shall be capable of continuously monitoring the jacking pressure and rate of advancement. Special care shall be taken when setting the pipe guard rails in the starter shaft to ensure correctness of the alignment, grade and stability.]

[1. Only tunneling equipment capable of fully supporting the face of the tunnel shall be used for pipe jacking work described.

2. Tunneling equipment selected for the project shall be compatible with the geotechnical information contained in this contract. The tunneling equipment shall be capable of tunneling through mixed face conditions without exceeding the settlement tolerances specified in paragraph "Settlement, Alignment and Tolerances."

3. Face pressure exerted at the heading by the tunneling machine shall be maintained as required to prevent loss of ground, groundwater inflows, and settlement or heave of the ground surface by balancing soils and groundwater pressures present.

4. Dewatering for groundwater control shall be allowed at the jacking and receiving pits only.]

5. Do not jack pipe casing until the concrete thrust block and tremie seal (if selected), and grouted soil zone in starter and receiving shafts have attained the required strength.

6. The pipe casing shall be jacked in place without damaging the pipe casing joints or completed pipe casing section.

7. After completion of the jacking operation between starter and receiver shafts, the lubricate material shall be displaced from between the pipe casing exterior and the surrounding ground by a cement grout. Pressure and the amount of grout shall be controlled to avoid pipe damage and displacement of the pipe and soil beyond the tolerances specified in paragraph "Settlement, Alignment and Tolerances." Grouting shall be accomplished promptly after pipe installation has been completed to prevent any surface settlement due to movement of soil material into the void space or loosened zone around the pipe casing.

8. Any pipe casing which has been damaged during installation shall be replaced by the Contractor at no additional cost. If a new replacement pipe casing is required extending from the starter to the receiver shaft, it shall be installed in conformance with the contract drawings and this section.

[9. Steel pipe casing joints shall be continuously welded with butt joint per AWS D1.1/D1.1M. The welds shall attain the full strength of the pipe and shall result in a full watertight section. The inner face of internal weld seam shall be flush with the pipe to facilitate the installation of the conveyance pipe in the pipe casing.

10. Perform all welding in accordance with requirements for shielded metal arc welding of AWS D1.5M/D1.5 for bridges and AWS D1.1/D1.1M for buildings and other structures.]

[11. Fiberglass pipe casing joints shall be fully watertight and shall attain the full strength of the pipe. Casing joints shall be field connected with sleeve couplings or bell and spigot type joints that utilize elastomeric sealing gaskets as the sole means to maintain joint water tightness.

12. The joint shall have the same outside diameter as the pipe so when the pipelines are assembled such that the joints are flush with the pipe inside and outside surface [to facilitate installation of he conveyance pipe in the pipe casing].]

13. [All excavated material from tunnel and shaft construction shall be disposed of away from the construction site.] [On-site storage of material must comply with Section 01 57 19.00 20 TEMPORARY ENVIRONMENTAL CONTROLS and must be stored in areas shown on site drawings.] [Stockpiling shall be permitted on the construction site and material shall be removed at regular intervals not exceeding [_____] hours.]

14. Monitor ground movements associated with the project and make suitable changes in the construction methods that control ground movements and prevent damage or detrimental movement to the work and adjacent structures and pavements.

15. Install instrumentation, take readings and provide the Contracting Officer with weekly reports containing measurements data with weekly reports to inspector. These actions are meant to supplement the Contractor's monitoring system and do not relieve

the Contractor of his responsibility, nor place on the Contracting Officer, responsibility for control of ground movement and protection of the project and adjacent structures. Instrumentation readings shall be continued for a period of [_____] weeks after pipe casings have been installed to establish that detrimental settlement has not occurred.

16. Unprotected mining of the tunnel bore is not permitted. The tunnel face and bore shall be fully supported at all times.

[17. A topographic survey will be performed by the Contractor before and after microtunneling and at [_____] week intervals for a period of [_____] weeks. Survey markers will be installed by the contractor at grid points located at [_____] m foot spacing over an area [_____] square meter square foot centered on the proposed tunnel alignments. Perform all remedial work including repaired if heave or settlement greater than [_____] mm inches is recorded.

18. Approval by the Contracting Officer of the topographic survey and final set of readings provided by the Contractor will constitute [partial] approval of the microtunneling phase of work.]

3.2.5 Ventilation

Adequate ventilation shall be provided for all cased tunnels and shafts. Follow confined space entry procedures. [Local burn permit regulations must be obeyed and complied with.] The design of ventilating system shall include such factors as the volume required to furnish fresh air in the shafts, and the volume to remove dust that may be caused by the cutting of the face and other operations which may impact the laser guidance system. The minimum amount of fresh air to be supplied shall be [_____] cubic m/s CFM. [Air testing shall be required for the specific conditions to ensure that the following gas concentration requirements are met:

Carbon Monoxide	$\leq$0.005 percent
Methane	$\leq$0.25 percent
Hydrogen Sulfide	$\leq$0.001 percent
Oxygen	$\geq$20.0 percent

]

3.2.6 Lighting

Adequate lighting shall be provided for the nature of the activity being conducted by workers for the microtunneling. Both power and lighting circuits shall be separated and thoroughly insulated with ground fault interrupters are required. Lights shall comply with requirements with regards to shatter resistance and illumination requirements.

3.2.7 Spoil Transportation

The soil transportation system shall match the excavation rate with rate of spoil removal. The system must also be capable of balancing groundwater pressures and adjustment to maintain face stability for he particular soil conditions of this project.

3.2.8 Pipe Jacking Equipment

The main jacking equipment installed must have a capacity greater than the anticipated jacking load. Intermediate jacking stations shall be provided by the Contractor when the total anticipated jacking force needed to complete the installation may exceed the capacity of the main jacks or the designed maximum jacking force for the pipe. The jacking system shall develop a uniform distribution of jacking forces on the end of the pipe by use of thruster rings and cushioning material.

3.2.9 Jacking Pipe

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NOTE: Some microtunneling methods utilize a temporary jacking pipe or shield that is replaced by a permanent casing or carrier pipe. This section applies to all jacking pipes, but it intended to ensure that temporary jacking pipes are covered by this section.
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NOTE: Jacking and Installation Information

1. The length of drive that is possible to achieve with particular equipment is dependent upon the jacking force required to push the pipe, the soil conditions and the depth of the pipe. The jacking force require is a function of many variables including the soil conditions, depth of the pipeline, annular space between the pipe and soil, lubrication of the pipe, material, diameter and strength.

2. When a slurry system is used by the Contractor, the composition of the slurry must be closely monitored for specific gravity and viscosity in certain soil conditions. With an auger soil removal system, the speed of rotation of the auger flight and the addition of water and/or compressed air must be closely monitored.
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In general, pipe used for jacking shall be smooth, round, have an even outer surface, and joints that allow for easy connections between pipes. Pipe ends shall be square and smooth so that jacking loads are minimized when the pipe is jacking. Pipe used for pipe jacking shall be capable of withstanding the jacking forces that will be imposed by the process or installation, as well as the final place loading conditions. The driving ends of the pipe and intermediate joints shall be protected from damage.

a. Any pipe showing signs of failure may be jacked through to the receiving shaft and removed. Other methods of repairing the damaged pipe may be used, as recommended by the manufacturer and subject to approval by the Contracting Officer.

b. The pipe manufacturer's design jacking loads shall not be exceeded during the installation process. The pipe shall be designed to take

full account of all temporary installation loads.

3.3 FIELD QUALITY CONTROL

3.3.1 Field Tests and Inspections

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NOTE: Indicate appropriate Section number and title in blank below using proper format per UFC 1-300-02.
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The Contractor shall perform field tests, and provide labor, equipment, and incidentals required for testing [, except that water and electric power needed for field tests will be furnished as set forth in [_____]]. The Contractor will product evidence, when required, that any item of work has been constructed in accordance with drawings and specifications.

3.3.2 Testing Requirements

For pressure test, use a hydrostatic pressure [_____] kPa psi greater than the maximum working pressure of the system. Hold this pressure for not less than [_____] hours. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

-- End of Section --