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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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SECTION 33 01 98

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SECTION 33 01 98

SLIP LINING OF EXISTING PIPING FOR LEVEE APPLICATIONS
05/13

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NOTE: This guide specification covers the requirements for the procurement, installation, and testing of slip lining for existing exterior piping.

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 item(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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PART 1 GENERAL

1.1 SUMMARY

This section of the specifications consists of the requirements and work needed to rehabilitate [an] existing pipe[s] in a levee system using the slip lining method by providing pipe liner[s], bulkheads, annular space grouting between the host and slip liner, performance testing as stated herein and providing all labor, materials and equipment necessary to accomplish the work as stated herein. In all instances, rehabilitation shall include installation of [a] liner pipe within an existing host pipe with a continuously grouted annular space. The size[s], type[s], and dimensions of the pipe liner[s] shall be selected by the Contractor and submitted for approval and shall include all connections, joints, and other appurtenances as required to complete the work.

1.2 MEASUREMENT AND PAYMENT

Payment will be made for work performed under this item in accordance with [the][each] pipe slip lined as shown in the bid schedule. Payment

includes all costs associated with labor, equipment, material, supervision, cleaning, inspection, sheeting, installation, safety, dust/erosion control, testing, site restoration and all other work specified or not which is reasonably required to provide a completed installation. Any item not specified shall be considered incidental to the work. Include all incidental cost in the bid price for the slip liner.

1.3 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 Reference Identifier (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.

ASTM INTERNATIONAL (ASTM)

ASTM C138/C138M	(2017a) Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C150/C150M	(2020) Standard Specification for Portland Cement
ASTM C403/C403M	(2008) Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance
ASTM C495/C495M	(2012; R 2019) Standard Test Method for Compressive Strength of Lightweight Insulating Concrete
ASTM C497	(2020; E 2020) Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile
ASTM C497M	(2020a) Standard Test Methods for Concrete Pipe, Concrete Box Sections, Manhole Sections, or Tile (Metric)

ASTM C581	(2020) Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures, Intended for Liquid Service
ASTM C939/C939M	(2016a) Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
ASTM C942	(2010) Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory
ASTM D2412	(2011) Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading
ASTM D3212	(2007; R 2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals
ASTM D3262	(2020) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe
ASTM D3350	(2012) Polyethylene Plastics Pipe and Fittings Materials
ASTM D3681	(2012; E 2014) Standard Test Method for Chemical Resistance of “Fiberglass” (Glass–Fiber–Reinforced Thermosetting-Resin) Pipe in a Deflected Condition
ASTM D3839	(2014) Standard Guide for Underground Installation of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
ASTM D4161	(2014) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
ASTM F477	(2014) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
ASTM F585	(2016) Standard Guide for Insertion of Flexible Polyethylene Pipe into Existing Sewers
ASTM F1697	(2009; R 2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Strip for Machine Spiral-Wound Liner Pipe Rehabilitation of Existing Sewers and Conduit
ASTM F1741	(2008; R 2016) Standard Practice for

	Installation of Machine Spiral Wound Poly (Vinyl Chloride) (PVC) Liner Pipe for Rehabilitation of Existing Sewers and Conduits
ASTM F2620	(2019) Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1	(2014) Safety and Health Requirements Manual

1.4 ADMINISTRATIVE REQUIREMENTS

1.4.1 Pre-Installation Conference

Within [_____] calendar days of notice to proceed, conduct a scope-validation meeting, including potential Sub-Contractors, and Contracting Officer to facilitate common agreement and understanding of the work to be performed. At this time, the resumes of Sub-Contractors, project superintendent or project manager shall be supplied to the Contracting Officer or be eliminated from consideration.

1.4.2 Detailed Work Plan

Submit a Detailed Work Plan not less than 30 days prior to commencement of work. The plan shall include but is not limited to the following:

a. Proposed construction sequencing and scheduling

b. Plan for removal of any obstructions encountered

c. Detail Drawings in an approved form, for [each] slip lining system including pipe manufacturer's instructions for installation

d. List of proposed products showing new diameter[s] of slip lining pipe[s] to be installed along with existing pipe diameter[s]

e. Specify all mandrel dimensions, including length[s], for each pipe to be slip lined

f. Provide maximum depth of cover over pipe[s]

g. Areas requiring special construction techniques

h. Proposed methods for flow control or by-pass to divert excessive flow away from a section of pipe if the need arises during the slip lining process

i. Proposed access and staging area[s]

j. Proposed method of re-establishment of connection[s] (if applicable)

k. Joints, gaskets, proposed Resins, Coatings, [_____], and other pertinent information as applicable

l. Dates of excavation and pipe placement, along with proposed work hours

m. Method for preventing damage to the host and liner pipe[s] using guide rails, pipe invert paving, or other applicable methods when the invert of the host pipe has deteriorated significantly

n. Method for waste grout recovery

o. Detailed plan for dealing with buoyant uplift of the liner pipe during grouting

p. Health & Safety Plan in compliance with EM 385-1-1.

q. Manufacturer's recommendation regarding methods for repair of damage to liner pipe following installation

r. List of proposed subcontractors

s. Written confirmation that the grouting procedures has been coordinated with the grout installer and the liner pipe manufacturer.

1.4.3 Sequencing and Scheduling

Submit plan for final approval of Construction Progress Schedule prior to commencing construction. Provide 72 hour notice to Contracting Officer prior to placing liner pipe[s]. Do not proceed with slip lining operations for pipe[s] that are likely to reach gauge operation elevation within 5 days as forecast by the National Weather Service. lay out the sequencing of work to minimize work stoppages as a result of high water. Additionally after liner pipe has been placed, make all reasonable attempts to grout the annulus prior to partial or total submergence of the pipe. In the event in which high water submerges a portion of a lined pipe prior to annular grouting, clean out the annular space using high pressure water jetting prior to grouting.

1.5 SUBMITTALS

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NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified 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 Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters 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.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Contractor Qualifications; G, DO
Grout Contractor Qualifications; G, DO
Pipe Inspection Procedures; G, DO
Construction Progress Schedule; G, DO
CCTV Recordings and Report Logs; G, DO
Digital Photographs and Report Logs; G, DO
Detailed Work Plan; G, DO
Analysis and Calculations; G, DO

SD-02 Shop Drawings

Bulkheads; G[, [_____]]

SD-03 Product Data

Liner Pipe; G[, [_____]]
Soluble Reactive Silicate Concrete Treatment Product; G, DO
UV Protective End Treatment; G, DO

SD-05 Design Data

Conveyance Capacity; G[, [_____]]
Downstream Scour Protection; G[, [_____]]
Structural Properties; G[, [_____]]

SD-06 Test Reports

Grout Trial Mix Tests

SD-10 Operation and Maintenance Data

Maintenance; G[, [_____]]

SD-11 Closeout Submittals

Manufacturer's Warranty; G, DO
Post-Installation CCTV Recordings and Report Logs; G, DO

Post-Installation Digital Photographs and Report Logs; G, DO

1.6 QUALITY ASSURANCE

1.6.1 Qualifications and Supervision

Submit Contractor Qualifications for slip lining piping, documenting their engagement in the successful installation of similar slip lining systems for at least [_____] years. Provide an experienced superintendent with experience in installation of similar slip lining systems. The superintendent shall be on site at all times and shall have full authority to direct the means, methods, equipment and personnel and performance of the work.

1.6.2 Grout Contractor Qualifications

Submit Grout Contractor Qualifications in letter form from the foam manufacturer stating that they are an approved applicator for that product, as well as the grout mix design, and test break results for that particular design. Reference paragraph GROUT MATERIALS AND MIXES for grout mix design requirements.

1.7 DELIVERY, STORAGE, AND HANDLING

Prevent injury or abrasion to liner pipe during loading, transportation, and unloading. Do not drop pipe from cars or trucks, nor allow pipe to roll down skids without proper restraining ropes. Use suitable pads, strips, skids, or blocks for each pipe during transportation and while awaiting installation in the field. Liner pipe shall be moved by machinery in a controlled manner. Do not allow liner pipe to roll down the levee embankment at any time. Handle and store in accordance with the manufacturer's published recommendations.

Remove slip liner pipe with cuts, gashes, nicks, abrasions, or any such physical damage which is deeper than 10 percent of the wall thickness from the site and replace with undamaged pipe at no additional cost to the Government.

1.8 WARRANTY

Submit [_____] copies of the signed Manufacturer's Warranty for all products within [_____] [days] [weeks] of final completion of the work.

PART 2 MATERIALS

2.1 DESIGN REQUIREMENTS

2.1.1 Conveyance Capacity

Provide slip lining pipe[s] designed to allow the maximum conveyance capacity possible, but in no case provide less capacity than currently exists while maintaining a 25 mm 1-inch minimum average annular space between the host pipe and liner pipe for grouting. In some cases capacity can be increased by improvement of entrance conditions and any such improvements must be submitted. Submit calculations that demonstrate how capacity is determined for the liner pipe. If there are circumstances which prohibit supplying a slip lining system that provides at least the current conveyance capacity for [each] [the] pipe to be slip lined, notify the Contracting Officer to determine an appropriate course of action.

2.1.2 Downstream Scour Protection

Consider the velocity of outlet flow and take appropriate action, if needed, to ensure that downstream scour protection is adequate. This may be addressed with rip rap, baffle blocks, energy dissipaters, or other means.

2.1.3 Design Criteria

The slip liner pipe system shall be designed by a licensed professional engineer to meet the standards outlined in the following sub-paragraphs. Submit calculations of the system's structural properties prior to construction. Support all assumptions utilized in calculations with product data, test reports, or referenced publications.

a. Design the new slip liner pipe system using the fully flood-loaded levee elevation to establish external hydrostatic pressure.

b. Design the new slip liner pipe system for maximum 5 percent ovality and a maximum allowable long term deflection of 5 percent.

c. Design the new slip liner pipe system using a safety factor of 2.5 for buckling and 2.0 for bending, wall crushing and buoyancy. Analysis for buckling shall be two-fold: to check for buckling from the grouting pressure of the liner pipe; and to check for buckling from external pressure of the underground water table. Ignore the cross-sectional shape distortion of the host pipe in the buckling analysis.

2.1.4 Analysis and Calculations

Submit detailed analysis and calculations, stamped by a licensed P.E., not less than 30 days prior to commencement of work. Demonstrate suitable application of products based on the following parameters:

a. Deflection

b. Confined buckling (for both Grouting case and the Flood Load case)

c. Long-term (50-year) hydrostatic buckling

d. Calculations verifying conveyance capacity and velocity of outlet flow meet the requirements as stated herein

e. Design Calculations showing that the proposed pipe satisfies the current design criteria neglecting any contribution of the host pipe[s]

f. Bulkhead designs and locations including vent and injection port location and proposed materials to be used in bulkhead construction

g. Buoyant force calculations during grouting

h. Grout mix designs per the requirements stated herein

i. Initial set time of grout

j. Estimated grout volume for each pipe

k. The maximum grout injection pressures proposed as well as maximum allowable grout injection pressures as provided by the pipe manufacturer

l. Proposed grout stage volumes

2.2 LINER PIPE

Provide pipe[s] constructed of corrosion resistant, thermoplastic, or thermosetting resin. Suitable pipe lining materials include solid wall High Density Polyethylene Pipe (HDPE), Machine Spiral Wound Poly Vinyl Chloride (PVC) Pipe, and Glass Fiber-Reinforced Plastic Pipe. Secure written product approval from the Contracting Officer before commencing any work.

a. Select liner pipe material to ensure that thermal expansion or contraction does not exceed a total of 13 mm 0.5 inches for the length of the pipe throughout the range of ambient air temperatures anticipated during the service life of the liner pipe[s]. Assume ambient air temperatures for this item to range from [___] degrees C F to [___] degrees C F.

b. Submit manufacturer's detailed product data with complete information on liner pipe materials (pipes, joints, gaskets, fittings, entrance bells), physical properties, dimensions, installation minimum/maximum allowable parameters such as maximum recommended external grout pressure, axial compressive stress, minimum bending radius or maximum joint angular deflection, etc. Include a manufacturer's certificate of compliance with specifications for proposed materials.

c. Pipe liner materials other than those stated below may be submitted for consideration and approval by the Contracting Officer based on meeting the design requirements as stated herein.

2.2.1 PVC Pipe(Machine Spiral Wound)

2.2.1.1 Profile Strip

Provide extruded PVC profile strip in accordance with the requirements of ASTM F1697 except as noted below.

a. Contrary to ASTM F1697, composite profile strip comprised of extruded PVC and a ferrous element necessary to provide long-term structural strength of the pipe is prohibited.

b. All profile strips shall be specifically applicable for installation and use in the project environment.

2.2.1.2 Joints

Joints shall meet the requirements of ASTM D3212, and gaskets meeting the requirements of ASTM F477.

a. The joint shall consist of a single, mechanical interlock between profile strips supplemented with sealant and is created continuously as the profile is wound into the pipe.

b. Once wound into place within the host pipe, joints shall be considered completed and the pipe shall not be intentionally or otherwise

expanded or permitted to translate in any direction at the joint.

c. The completed liner pipe shall be provided such that neither the outside diameter of the pipe is increased nor the internal diameter of the pipe is decreased at the joint.

d. Joints shall be water-tight over the range of head pressure expected for the pipe.

2.2.2 Solid-Wall High Density Polyethylene Pipe (HDPE)

2.2.2.1 Pipe

a. Pipe and pipe fittings shall be manufactured from high density compounds in accordance with ASTM D3350, cell classification 345464C with a designation of PE 3408 and a minimum Standard Dimension Ratio (SDR) of 32.5.

b. Pipe shall be solid wall with a smooth interior and exterior with no corrugations or ferrous elements.

c. Each pipe segment shall be marked on the inside and outside with a coded number which identifies the manufacturer, SDR, size, materials, machine, date and shift on which the pipe was extruded.

d. Pipe[s] shall be specifically applicable for installation and use in the project environment.

2.2.2.2 Joints

a. Joints shall be water-tight over the range of head pressure expected for the pipe.

b. Joints shall be butt-fused in accordance with ASTM F2620 and the manufacturer's recommendations or shall be capable of being joined into a continuous length by an interlocking method such that joints meet the requirements of ASTM D3212. Screw-type or threaded joints will not be allowed unless a positive lock is included in the joint system or the perimeter of the joint is extrusion welded at the bearing assembly, prior to insertion.

c. Internal beads resulting from butt fusion shall be limited to a 6 mm 0.25 inch projection perpendicular to the inside wall of the pipe. Trim beads larger than 6 mm 0.25 inch 360 degrees around the interior of the pipe. External beads resulting from butt fusion need not be trimmed unless the bead projection will negatively impact pipe installation or migration of annulus grout.

2.2.3 Glass Fiber-Reinforced Plastic Pipe

2.2.3.1 Pipe

Provide centrifugally cast fiberglass reinforcement plastic mortar pipe (CCFRMP) in accordance with ASTM D3262, cell classification Type 1, Liner 2, Grade 3. All pipes shall be specifically applicable for installation and use in the project environment.

a. Minimum pipe stiffness shall be [_____] kPa psi when tested in accordance with ASTM D2412.

b. The glass shall be a commercial grade of E-type glass fibers with the amount, location and orientation of the chopped glass-fiber reinforcement specifically designed for each application.

c. Sand shall be minimum 98 percent silica kiln-dried and graded.

d. The polyester wall resin shall be an isophthalic, orthophthalic or other approved resin with a minimum tensile elongation of 2 percent.

e. Fiberglass liner shall be shown by tests to be resistant to long-term corrosion. Testing shall be performed in accordance with ASTM D3681 using 1.0N sulfuric acid for sanitary sewage, and ASTM C581 for industrial sewage.

f. Each pipe segment shall be marked on the inside and outside to identify the manufacturer's number, diameter, stiffness, ASTM designation and lot number.

2.2.3.2 Joints

a. Provie pipe with joints designed so that neither the outside diameter of the pipe is increased nor the internal diameter of the pipe is decreased at the joint.

b. Joints shall be water-tight over the range of head pressure expected for the pipe.

c. Joints shall meet the performance requirements of ASTM D4161. Field conntect pipe[s] with low-profile, fiberglass bell-spigot joints or flush fiberglass bell-spigot joints, when the fit requires. Utilize elastomeric sealing gaskets as the sole means to maintain joint water-tightness. Gaskets shall meet the requirements of ASTM F477. Joints at tie-ins, when needed, may utilize gasket-sealed closure couplings.

2.2.4 UV Protective End Treatment

All slip liner pipes constructed of materials that are not UV stabilized (i.e. fiberglass pipe) that terminate at an open end or headwall shall receive a factory-applied coating on the interior surface of the pipe to resist deterioration from ultraviolet radiation. The UV protective coating shall be applied for a distance inside the pipe equal to two times the inside diameter of the liner pipe. In the event that field cutting is necessary, no additional coating will be required for the cut end.

a. Coating color shall be light gray or similar shade subject to approval by the Contracting Officer.

b. Nicks, scratches and minor abrasions to the coating shall be touched up in the field following final installation.

2.3 GROUT MATERIALS AND MIXES

2.3.1 Grout For Annular Space

Provide grout for the annular space in accordance with this Specification and with the manufacturer's published recommendations. The grout shall be nonstructural or structural based upon the type of slip liner system

provided. If the pipe liner provided cannot meet the stated requirements for factor of safety against buckling or crushing, then a structural grout must be used regardless of the pipe liner system used in order to fulfill the factor of safety requirements as stated herein.

2.3.2 Grout Mix for Annulus Grouting

2.3.2.1 Cement

Comply with ASTM C150/C150M.

2.3.2.2 Water

Use only potable water to prepare grout.

2.3.2.3 Admixtures

Select admixtures to meet performance requirements, improve pumpability, control set time and reduce segregation. Admixtures shall not be biodegradable.

2.3.2.4 Compressive Strength

2.3.2.4.1 Structural Grout

The grout 28-day compressive strength shall be that determined during the design and submitted for approval. Test 28-day compressive strength in accordance with ASTM C942.

2.3.2.4.2 Nonstructural Grout

The grout shall have a minimum penetration resistance of [690][_____] kPa [100][_____] psi in 24 hours when tested in accordance with ASTM C403/C403M and a minimum compressive strength of [2415][_____] kPa [350][_____] psi in 28 days when tested in accordance with ASTM C495/C495M.

2.3.2.5 Mix Design

Design a grout mix and installation procedure to completely fill the annular space based upon, but not restricted to the list below (a. - g.), such that the slip liner pipe will not float (either by external restraint or internal weighting). The grout shall maintain an appropriate viscosity as tested in accordance with ASTM C939/C939M. Verify the density in conformance with ASTM C138/C138M or by other methods as approved by the Contracting Officer.

a. Size of annular void

b. Absence or presence of water

c. Sufficient strength and durability to achieve the design requirements as stated herein

d. Provide adequate retardation for placement

e. Provide less than 1 percent shrinkage by volume

f. Distance between grout injection ports

g. Heat of hydration compatible with pipe material in accordance with pipe manufacturer's recommendation

2.3.2.6 Mixers and Pumps

Mix the materials in equipment of sufficient size and capacity to provide the desired amount of grout material for each stage of the grouting operation. The system shall mix the grout to a homogeneous consistency and deliver grout to the injection point [under a normal range of operating conditions] [at a steady pressure with a non-pulsating pump at the mix tank]. The equipment shall be capable of mixing the grout at densities required for the approved procedures and shall also be capable of changing mixing parameters as dictated by field conditions at any time during the grouting operation.

2.3.2.7 Pressure Gauges

a. Pressure gauges shall be suitable for use in the grouting environment and have a working range between 1.5 to 2.0 times the design grout pressures, and have accuracy within 0.5 percent of full range.

b. Provide, at a minimum, one pressure gauge at the point of injection and one pressure gauge at the grout pump.

2.3.3 Grout Trial Mix Tests

a. Structural Grout: Provide Grout Trial Mix Test Results with viscosity, density, and 28-day minimum compressive strength. Also provide the grout working time before a 15 percent change in viscosity occurs.

b. Non-structural Grout: Provide Grout Trial Mix Test Results with viscosity, density, 24-hour penetration resistance set time, and 28-day minimum compressive strength. Also provide the grout working time before a 15 percent change in density or viscosity occurs.

2.3.4 Bulkhead Concrete

Design a low slump concrete mix to form a bulkhead at each end of the pipe to retain the annular grout. Low slump concrete shall consist of cement, fine and coarse aggregate, water, and an air-entraining admixture. Concrete shall be thoroughly compacted into the prepared void by tamping, rodding, ramming, etc. Forms may be used to confine the concrete. The temperature of the in situ concrete (i.e., headwall or gatewell structure), adjacent air, and bulkhead concrete shall be above 4 degrees C 40 degrees F during placement.

PART 3 EXECUTION

3.1 PREPARATION AND INSPECTION

The Contracting Officer makes no guarantee regarding the information, data, and physical condition of underground facilities or existing pipe[s]. Before commencing with any work, or ordering any materials, physically measure the length and diameter and inspect the existing pipe[s] designated to receive a pipe liner to verify that the rehabilitation plan is appropriate and meets the requirements of EM 385-1-1. For pipes large enough and safe to enter, a walk-through inspection with digital photography is preferred when confined space entry procedures are

followed. Inspect small or unsafe pipes using CCTV. Submit pipe inspection procedures to locate breaks, obstacles and connections in pre-construction submittals for approval. Note all connections and any conditions which may prevent proper installation of the liner. Correct these conditions prior to liner installation. Coordinate slip lining efforts with the Contracting Officer and the owner of the affected pipe. Submit the CCTV Recordings and Report Logs and/or Digital Photographs and Report Logs prior to pipe liner installation. Base the work plan on a thorough review of the inspection video and/or digital photographs and report logs.

3.1.1 Safety

Note any areas that may involve entry and/or work in confined spaces and [address in][provide as a supplement to] the project Health and Safety Plan provided under Section 01 35 26 GOVERNMENTAL SAFETY REQUIREMENTS prior to performing work in these areas.

3.1.2 Control of Flow

Provide for maintenance and control of flow as necessary for effective inspection and satisfactory installation of the slip liner and grout. Such work shall include by-pass pumping or berming and dewatering for submerged pipes. Submit proposed means and methods for control of flow with the pipe inspection procedures.

3.1.3 Bypass Pumping

If required, provide for continuous bypass flow around the section or sections of pipe designated for the liner process. Provide pump and bypass lines of adequate capacity to handle the necessary flow.

3.1.4 Pre-Lining Cleaning

Prior to the man-entry or CCTV inspection and installation of the slip liner pipe, thoroughly clean the host pipe[s] designated to receive the liner. Cleaning shall constitute removal of all debris, solids, roots, deposits, and other matter which would preclude proper installation of the slip liner pipe and annulus grout. Perform cleaning such that no damage occurs to the host pipe. Handle water used for flushing and cleaning [the] pipe[s] prior to slip liner system installation to comply with regulatory agencies having jurisdiction regarding erosion prevention and sediment control procedures for storm water discharge.

3.1.5 Insertion and Pulling of Mandrel

Prior to commencing any work, pull a mandrel through all host pipes too small or unsafe to enter in order to check for deformation, joint deflection or obstructions prior to ordering any pipe liner materials. Host pipes large enough and safe to enter may be verified through man-entry, mandrel or both at the Contractor's discretion.

a. The mandrel length of liner pipe shall be equal to the liner pipe joint length.

b. The mandrel shall have an outside diameter not less than that of the proposed slip liner pipe plus 2-inches, shall be equal to the pipe joint length of the liner pipe to be installed and shall have a stiffness equal to or greater than that of the slip liner pipe. When

a segment of slip liner pipe is used as a mandrel, it shall not be used as a permanent slip liner pipe.

3.2 EXCAVATION

Perform work utilizing existing points of entry including headwalls, manholes, etc. Excavation along the length of the host pipe (between headwalls/manholes) is strictly prohibited. In the event that it becomes necessary to perform an excavation, obtain written confirmation that an excavation is warranted from the Contracting Officer. If an excavation is required, excavations shall be minimal and comply with local, State, and Federal regulations. Repair any excavation of levee material according to [USACE regulations][Section 31 00 00 EARTHWORK] regarding acceptable fill material, benching and compaction requirements.

3.3 INSTALLATION

3.3.1 General

a. Restore project site to original condition prior to final payment. Include the cost to repair all damages resulting from the work in the base bid.

b. Point repairs, deemed necessary at any point on the existing pipeline prior to slip lining shall be approved by the Contracting Officer prior to start of work, require locating the insertion pit at the point repair location.

c. Locate and identify all connections, excavate, and disconnect prior to the slip line pipe insertion. Upon completion of insertion of the slip line pipe and a 24-hour pipe relaxation period, expedite the reconnection of cross connections as quickly as possible. Provide for temporary pumping and/or control of flow from each connection until final reconnection has been performed. Connections are to be reopened and trimmed to a neat, clean opening concentric with the connection pipe in a manner that provides a water tight seal between the liner pipe and the connection pipe.

d. In all instances, the liner pipe shall be a fixed diameter and shall not be expanded intentionally or otherwise.

e. Maximum and minimum lay lengths shall be in accordance with manufacturer's requirements and any constraints based on work limits [as prescribed by the Contracting Officer].

f. Insertion may proceed from either upstream or downstream as suitable access is available.

g. Use sub-aqueous pipe lubricant meeting the specifications of ASTM C497M ASTM C497 Section 12 in accordance with pipe manufacturer's installation instructions. Use only lubricants approved by the pipe manufacturer.

h. Use caution to prevent jagged edges from damaging the slip liner pipe during insertion when the invert of host pipe has deteriorated significantly. In such cases, describe in the work plan how damage to the host and liner pipe[s] will be prevented using guide rails, pipe invert paving, or other applicable methods.

i. Consider thermal expansion/contraction effects such that the ends of the slip liner pipe are flush with the existing headwall/manhole to within 12 mm 0.5 inch. Where a slip liner pipe meets a gatewell or flapgate, the slip liner pipe cannot project beyond the end of the host pipe. Reasonable attempts shall be made to achieve a flush surface between the slip liner pipe and the host pipe. Delay trimming of the liner pipe[s] for 28 days after completion of grouting.

j. Take necessary precautions to maintain line and grade of the host pipe and avoid flotation of the liner pipe. Construct all blocking, if used, of inert, non-ferrous material, and install in accordance with manufacturer's recommendations.

k. Drilling holes in the slip liner pipe for any reason is prohibited.

l. Prior to grouting, visually inspect all slip liner pipe joints to check the integrity of joints and verify that the liner has not been damaged during installation. Repair if needed using liner manufacturer's recommended procedure.

m. Sealing at manholes, if applicable: A tight seal is required at manholes, openings, or abutments with no annular gaps. Rebuild manholes between linear ends resulting in a smooth, continuous flow line through the manhole.

n. At the completion of construction the exposed ends of [the][all] slip lined pipe[s] shall have a clean, finished look with no visible signs of grout vents, injection tubes, etc.

3.3.2 Machine Spiral Wound PVC Pipe

a. Install machine Spiral Wound PVC Liner Pipe in accordance with ASTM F1741, manufacturer's recommendations and the provisions of this Section. In the event of a conflict, the most restrictive of the three shall govern.

b. No mechanical pulling or pushing force (such as backhoe bucket or winch cable) shall be exerted on the ends of the pipe during installation.

c. In all instances, the liner pipe shall be a fixed diameter and shall not be expanded intentionally or otherwise.

3.3.3 Solid-Wall High Density Polyethylene Pipe (HDPE)

a. Install Solid-Wall High Density Polyethylene (HDPE) Liner Pipe in accordance with ASTM F585, manufacturer's recommendations and the provisions of this Section. In the event of a conflict, the most restrictive of the three shall govern.

b. Allow the installed pipe to relax and cool following installation in accordance with manufacturer's recommended time, but not less than 24 hours, prior to any reconnection of lines, grouting of the annulus, or backfilling of the insertion pit. Staged grouting is essential, especially for larger diameter pipes, in order to keep thermal expansion low and to prevent a reduction in the pipe diameter.

c. The slip liner pipe shall be free of foreign inclusions and visible defects such as cracks, creases, unpigmented or nonuniformly pigmented

pipe. Cut the ends of the pipe squarely and cleanly so as not to adversely affect joining or connecting. Field cuts shall be de-burred and free of defects.

d. Sections of slip liner pipe shall be joined and inserted into the host pipe until a continuous liner pipe is created along the entire length of the host pipe, in accordance with pipe manufacturer's recommendations.

3.3.4 Glass Fiber-Reinforced Plastic Pipe

Install Glass Fiber-Reinforced Plastic Liner Pipe in accordance with ASTM D3839, manufacturer's recommendations and the provisions of this Section. In the event of a conflict, the most restrictive of the three shall govern.

3.3.5 Bulkheads for Annulus Grouting

a. Once the slip liner pipe has been installed; construct bulkheads in sequence from upstream to downstream at the end of each pipe segment; including gatewells and manholes located intermediately along the pipe length to be slip lined. The bulkhead shall have a minimum length measured along the long axis of the pipe of 300 mm 1 foot, or the thickness of the headwall, whichever is greater. The lengths of grouting ports shall be staggered such that the entire run of the pipe can be completely grouted.

b. Shop drawings shall include all locations of the grout/air ports and sketches of the proposed bulkheads, as well as the lengths of each grouting port. Shop drawings shall include manufacturer's literature for accessories and form coating materials. Submit the proposed materials, dimensions, location of grout injection ports, vent tubes, etc.

c. Construct bulkheads a minimum of 24 hours after the completion of the slip liner insertion process to allow for thermal equilibrium between the slip liner pipe and the host pipe conditions and at most 72 hours after completion of the slip liner insertion process to minimize the exposure of the annulus to debris from a rainfall event. The annulus shall be cleaned if a local rainfall event or a river flooding event partially or wholly submerges the pipe prior to bulkhead construction.

d. Place vent holes at the crown and the invert in the downstream bulkhead. An access hole, sized to facilitate the method of grout input and an air vent shall be placed at the crown in the upstream bulkhead. The vent holes in the downstream bulkhead are plugged as soon as grout begins to flow out each hole. The air vent in the upstream bulkhead is kept clear until grout begins to flow out of the vent.

e. The bulkheads shall be hand-finished to a professional quality appearance. After a curing period and pressure washing of the headwalls, a Soluble Reactive Silicate Concrete Treatment Product shall be applied over the entire headwall surface, including the bulkheads.

3.3.6 Annulus Grouting

Following construction of the bulkheads, fill annular space with grout

between the ID of the host pipe and the OD on the liner pipe.

a. Notify the Contracting Officer at least 24 hours in advance of grouting operations.

b. Grout the pipe from downstream to upstream, unless prohibited by access, along its entire length with cementitious grout. Place the grout by either gravity flow or by low pressure pumping to completely fill all voids within the annular space without causing deformation of the liner. The grout extends the full length of the pipe.

c. Ensure the liner pipe maintains the designed line and grade while the annulus grout is placed in uniform lifts. Place annulus grout in lifts of [_____] to avoid floating of the liner and to ensure a uniform grout thickness.

d. The gauged grout pressure at the pipe shall not exceed that of the pipe manufacturer's recommendation or 35 kPa 5 psi, whichever is smaller. Regardless of the pressure, the Contractor is solely responsible for any damage or distortion to the slip liner pipe due to grouting.

e. Remove water in annular space immediately prior to grout pumping to maintain the correct water-cement ratio of the grout mixture.

f. Drilling of additional injection holes from the surface or through the liner pipe to facilitate grouting is prohibited.

g. Continue injection of grout until all of the following conditions have been achieved unless otherwise approved by the Contracting Officer:

   (1) The estimated volume of grout has been injected, as measured at the pump.

   (2) The exhausted grout recovered at each vent is between 85 and 115 percent of the density of the freshly injected grout.

h. No hardened grout is permitted in the liner pipe invert after completion of grouting operations.

i. When cold weather grouting is performed (temperature is between 0-5 degrees C 32-40 degrees F during and after grouting) the following conditions shall be met:

   (1) Temperature of the grout mix must be 15 degrees C 60 degrees F or higher at the time of pumping.

   (2) The use of insulation/concrete blankets over areas of the levee behind the headwalls where the minimum cover above the frost line is not met for a period of seven days.

j. Cold weather grouting when the temperature is below 0 degrees C 32 degrees F during and after grouting the following conditions shall be met:

   (1) Temperature of the grout mix must be 15 degrees C 60 degrees F or higher at the time of pumping.

(2) The use of insulation/concrete blankets over areas of the levee behind the headwalls where the minimum cover above the frost line is not met for a period of seven days.

(3) The use of an internal heater in the pipe that does not exceed the pipe's maximum localized temperature for the first 24 hours after grouting.

3.4 TESTING AND ACCEPTANCE

3.4.1 Rework

Remove any material that has not received prior approval from the Contracting Officer or is not accepted as suitable work by the Contracting Officer and replaced or repaired to the satisfaction of the Contracting Officer with an approved method/material at the Contractor's sole expense. Materials left in place, but not meeting these Specifications, will be paid for at a reduced price.

3.4.2 Grout Testing

3.4.2.1 Density

Conduct field grout density testing on non-structural grout only. Measure density in accordance with ASTM C138/C138M not less than two times per hour in the field during grouting operations. Grout that exceeds ±48 kg/cubic meter ±3 lb/cubic foot of the design density shall be rejected.

3.4.2.2 Compressive Strength

Engage the services of an independent, ASTM/AASHTO accredited testing laboratory to collect and test specimens associated with the strength requirements of this Section.

3.4.2.2.1 Structural Grout

a. Collect, transport, cure, test and report samples in accordance with ASTM C942, except as stated below.

b. Contrary to ASTM C942, collect and test specimens based on the more restrictive of the following criteria:

(1) One specimen (consisting of one, 3-gang mold) for each grouting event for each pipe collected at approximately the mid-point of the grouting operations.

(2) One specimen (consisting of one, 3-gang mold) for each 14 cubic m 500 cubic feet of grout placed for each pipe.

c. Test all specimens for compressive strength at 28 days. Additional specimens and tests may be performed at the Contractor's discretion.

3.4.2.2.2 Nonstructural Grout

a. Collect, transport, cure, test and report samples in accordance with ASTM C495/C495M.

b. Collect four specimens (75 mm x 150 mm 3 inch x 6 inch cylinders) for each pipe at approximately the mid-point of the grouting operation.

c. Test all specimens for compressive strength at 28 days. Additional specimens and tests may be performed at the Contractor's discretion.

d. Tests and companion specimens associated with oven-dry unit weight (ASTM C495/C495M Item 9) are not required.

3.4.3 Acceptance Inspection

After all work is completed, perform an inspection of [the][each] pipe that received a pipe liner, documenting the post-installation conditions. For pipes large enough and safe to enter, a walk-through inspection with digital photography is preferred when confined space entry procedures are followed. Small or unsafe pipes shall be inspected using CCTV. Submit the Post-Installation CCTV Recordings and Report Logs and/or Post-Installation Digital Photographs and Report Logs.

a. Infiltration of ground water or annular grout through the liner pipe will be a basis for non-acceptance.

b. All connections shall be accounted for and be unobstructed.

3.4.3.1 Defects

All defects discovered during the post-installation inspection shall be corrected before the work under the Contract will be considered for Substantial Completion. After the defects, if any, are corrected in accordance with manufacturer's recommendations, the affected pipe segments shall be inspected a second time as a follow-up inspection. All follow-up inspections will be performed by the Contractor, and all costs associated with such follow-up inspections associated with the correction of work shall be borne by the Contractor.

3.4.3.2 Final Acceptance

Provide final digital photographs and/or video and report logs to the Contracting Officer for review and approval of finished work for [the][each] pipe slip lined prior to receiving final payment.

3.5 MAINTENANCE

Submit manufacturer's recommendations for care and maintenance upon completion of installation.

-- End of Section --