**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated July 2023**
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DIVISION 33 - UTILITIES

SECTION 33 01 98

SLIP LINING OF EXISTING PIPING FOR LEVEE APPLICATIONS

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SECTION 33 01 98

SLIP LINING OF EXISTING PIPING FOR LEVEE APPLICATIONS
**02/23**

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**NOTE: This guide specification covers the requirements for the procurement, installation, and testing of slip lining for existing piping within levees only. Other specifications are available that cover the specific slip lining technologies provided here. It is encouraged to provide this specification to non-federal levee sponsors as an example to be used on rehabilitation projects associated with levee systems.**

**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 specification discusses the requirements and work needed to rehabilitate existing gravity pipes in a levee system related to pipe liner materials, bulkheads, annular space grouting between the host and liner pipe, performance testing, labor, and other materials and equipment necessary to accomplish the work as stated herein. Rehabilitation will most often consist of installing a liner pipe within an existing host pipe and grouting the annular space, but in some cases a

close-fit or spray-on liner may be used which will render grouting unnecessary. The term "slip lining" is generic within this specification and includes sectional (HDPE, GFRP,) spiral-wound PVC, close-fit (CIPP, fold and form), and spray-on (cementitious, epoxy) liners. Although slip lining levee pump station discharge pipes may be possible, this specification will not endorse a material or method for it or any other pressurized pipe system. Submit details of the proposed slip lining materials and methods, including any necessary appurtenances for approval..

## 1.2 MEASUREMENT AND PAYMENT

Payment will be made for work performed under this item in accordance with [the][each] pipe lined as shown in the bid schedule. Payment includes all costs associated with labor, equipment, material, supervision, cleaning, inspection, sheeting, water control, installation, safety, dust/erosion control, testing, site restoration and all other work specified or not which is reasonably required to provide a completed installation. Items not specified are 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 | (2022) Standard Specification for Portland Cement |
| ASTM C403/C403M | (2008) Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance |

| | |
|---|---|
| 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 | (2022) Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method) |
| ASTM C942/C942M | (2021) Standard Test Method for Compressive Strength of Grouts for Preplaced-Aggregate Concrete in the Laboratory |
| ASTM D2412 | (2021) Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading |
| ASTM D3212 | (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 | (2021) 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; R 2021) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe |
| ASTM F585 | (2016; R 2021) Standard Guide for Insertion of Flexible Polyethylene Pipe into Existing Sewers |
| ASTM F1735 | (2021) Standard Specification for Poly (Vinyl Chloride)(PVC) Profile Strip for PVC Liners for Rehabilitation of Existing Man-Entry Sewers and Conduits |

| | |
|---|---|
| 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 F1743 | (2016) Standard Practice for Rehabilitation of Existing Pipeline and Conduits by Pulled-In-Place Installation of Cured-In-Place Thermosetting Resin Pipe (CIPP) |
| ASTM F2019 | (2011) Standard Practice for Rehabilitation of Existing Pipelines and Conduits by the Pulled in Place Installation of Glass Reinforced Plastic (GRP) Cured-in-Place Thermosetting Resin Pipe (CIPP) |
| ASTM F2620 | (2020a; E 2021) Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings |
| ASTM F3190 | (2021) Standard Practice for Heat Fusion Equipment (HFE) Operator Qualification on Polyethylene (PE) and Polymide (PA) Pipe and Fittings |

U.S. ARMY CORPS OF ENGINEERS (USACE)

| | |
|---|---|
| EM 385-1-1 | (2014) Safety -- Safety and Health Requirements Manual |
| EM 1110-2-1601 | (1991; 1994 Change 1) Engineering and Design -- Hydraulic Design of Flood Control Channels |

## 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, supply the resumes of Sub-Contractors, project superintendent or project manager to the Contracting Officer or be eliminate 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 includes 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 for each pipe to be slip lined

f. Details for procedures of area requiring special construction techniques

g. Proposed methods for water flow control or diversion during the slip lining process

h. Proposed access and staging area[s]

i. Proposed method for permanently or temporarily plugging and re-establishing lateral connections to the pipe to be slip lined when applicable

j. Joints, gaskets, proposed resins, coatings, [_____], and other pertinent information as applicable

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

l. 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

m. Method for waste grout recovery

n. Detailed plan for addressing buoyant forces of the liner pipe during grouting

o. Health & Safety Plan in compliance with applicable portions of EM 385-1-1.

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

q. List of proposed subcontractors with qualifications and work history

r. Written confirmation that the grouting procedures have been coordinated with the grout installer.

### 1.4.3 Sequencing and Scheduling

Installation can not proceed until the contractor's Construction Progress Schedule has been approved. The Contracting Officer must be provided 72 hours notice prior to placing liner pipe[s]. Do not proceed with slip lining operations for pipes that are likely to reach gauge operation elevation within 5 days as forecast by the National Weather Service. Sequence work to minimize stoppages as a result of high water. In the event high water threatens to inundate a lined pipe prior to annular grouting, make every effort to complete the bulkheads and plug all holes through the bulkheads or otherwise prepare the project so no water enters the annular space. In most cases, the majority of water can be drained and any remaining water "pushed" out during the grouting process, but the Contracting Officer will determine if any special effort to clean the annular space is required and to what degree.

## 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

Superintendent and 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

Analyses and Calculations; G, DO

Bulkhead Mix Design; G, DO

Grout Trial Mix Tests; G, DO

Pre- And Post-Slip Lining Conveyance Capacity; G, DO

SD-02 Shop Drawings

Bulkheads; G[, [_____]]

SD-03 Product Data

Liner Pipe; G[, [_____]]

Soluble Reactive Silicate Concrete Treatment Product; G, DO

UV Protection; G, DO

SD-05 Design Data

Conveyance Capacity; G[, [_____]]

Downstream Scour Protection; G[, [_____]]

Structural Properties; G[, [_____]]

SD-06 Test Reports

Annular Space Grout Test Reports

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 Superintendent and Contractor Qualifications for slip lining pipe lining systems for at least [_____] years. Provide a superintendent on site at all times and with 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

Pipe sections are to be handled and stored in such a way as to prevent damage to the pipe or creating a safety hazard to workers; this includes using restraining measures to prevent uncontrolled rolling or dropping. Handle and store in accordance with the manufacturer's published recommendations. Reference paragraph LINER PIPE for lists actions for damaged pipe sections.

## 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

Meet or exceed the conveyance capacity of the host pipe with the liner pipe, while maintaining a minimum 25-mm 1-inch wide annular space between the host and liner pipes (for systems requiring grouting), unless a government-reviewed and approved study indicates a reduced capacity is allowed. In some cases, the capacity can be increased with improvements to the entrance geometry, but any such improvements must be submitted for approval. Submit all pre- and post-slip lining conveyance capacity calculations for approval, including supporting information for assumptions.

### 2.1.2 Downstream Scour Protection

Verify the existing scour protection is sufficient to prevent erosion at the outlet of slip lined pipes (understanding that slip lining a pipe usually increases the outflow velocity), or determine the new materials needed using current design guidance, such as EM 1110-2-1601, to prevent erosion.

### 2.1.3 Design Criteria

Furnish a slip liner pipe system designed by a licensed professional engineer meeting 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. Structurally design the new slip liner pipe system using the fully flood-loaded levee elevation to establish external hydrostatic pressure. The Contractor can submit a request to the Contractor Officer to lower the design loading for circumstances such as a pipe within highly plastic clays subject to brief loadings, or portions of

pipes that fill with flood water and provide equalization and 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. Perform separate buckling analyses for the pressures associated with grouting the annular space and for a full hydrostatic loading. Ignore the cross-sectional shape distortion of the host pipe in the buckling analysis.

2.1.4 Analysis and Calculations

Submit detailed analyses 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 the grouting case and the full flood load case)

c. Long-term hydrostatic buckling (may be available from the pipe manufacturer)

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 from the host pipe

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 grouting stage to prevent buoyancy of the liner pipe and/or the volume of water required to counteract buoyancy in the event that the liner pipe floats and impacts the design flow of the pipe. Water can be used within the liner pipe to weigh down the floated sections before the grout sets.

k. The maximum grout injection pressure as limited by the pipe manufacturer.

2.2 LINER PIPE

Standard 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 (GFRP). Close-fit liners such as cured-in-place-pipe (CIPP), fold and form PVC, and cementitious or epoxy spray on liners, are generally considered less desirable since they do not provide an annular space for grouting and may therefore only be used in cases where the host pipe has not experienced penetrating

defects. The government will decide if close-fit liners are suitable based on the condition of the host pipe as determined using the post-cleaning camera inspection recording.

a. Select liner pipe material to ensure that the anticipated maximum thermal expansion or contraction does not interfere with closure devices or allow the liner to retreat into the host pipe past the headwall 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.

**********

**NOTE: Determining the temperature limits is somewhat speculative and using the extreme air temperatures for the area may be overly conservative considering the potential for latent heat/cooling from the ground and static air due to closed gates.**

**********

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.

d. Repair slip liner pipes with cuts, gashes, nicks, abrasions, or other physical damage deeper than 10 percent of the wall thickness to the Government's satisfaction or replace at no additional cost to the Government. Pipes sections containing cracks or fractures that penetrate the full depth of the wall thickness will be rejected and replaced at no cost to the government.

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 F1735. Exposed ferrous elements on the outer side of the liner pipe are only allowed in cases where the annular space will be grouted.

2.2.1.2 Joints

a. The male portion of the joint is formed into one side of the profile of the PVC strip while the female portion is formed into the other side so they create a watertight seal when mechanically interlocked as it is wound into place. A sealant [may][must] be used to supplement the joint as [permitted][recommended][required] by the manufacturer..

b. Once wound into place within the host pipe, the spiral wound liner is not to be intentionally or otherwise expanded or contracted to change

its diameter.

2.2.2 Solid-Wall High Density Polyethylene Pipe (HDPE)

2.2.2.1 Pipe

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

b. Provide solid wall pipe with a smooth interior and exterior with no corrugations or exposed ferrous elements.

c. Mark each pipe segment 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.

2.2.2.2 Joints

a. Butt-fuse joints in accordance with ASTM F2620 and the manufacturer's recommendations or join into a continuous length by an interlocking method (typically proprietary) meeting 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 exterior perimeter of the joint is extrusion welded prior to insertion.

b. Any external beads greater than 6 mm 0.25 inch in height as a result of butt-fusion welding at a joint will require that the corresponding internal bead be trimmed. 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 glass-fiber-reinforced (includes thermosetting-resin and polymer mortar) plastic pipe in accordance with ASTM D3262, cell classification Type 1, Liner 2, Grade 3.

a. Provide minimum pipe stiffness of [_____] kPa psi when tested in accordance with ASTM D2412.

b. Provide glass consisting of 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 must be minimum 98 percent silica kiln-dried and graded.

d. Provide polyester wall resin that is an isophthalic, orthophthalic or other approved resin with a minimum tensile elongation of 2 percent.

e. Show by testing that the fiberglass liner is resistant to long-term corrosion. Perform testing in accordance with ASTM D3681 using 1.0N sulfuric acid for sanitary sewage, and ASTM C581 for industrial sewage.

f. Mark each pipe segment on the inside and outside to identify the manufacturer's number, diameter, stiffness, ASTM designation and lot number.

2.2.3.2 Joints

a. Provide pipe with joints designed so the internal diameter of the pipe is not decreased at the joint.

b. Meet the performance requirements of ASTM D4161. Field connect pipe[s] with low-profile, fiberglass bell-spigot joints or flush fiberglass bell-spigot joints, so that there is no less than 25 mm 1 inch of annular space between the outside face of the joint and host pipe. Utilize elastomeric sealing gaskets, meeting the requirements of ASTM F477, as the sole means to maintain joint water-tightness.

2.2.4 Cured-In-Place Pipe (CIPP)

It is recommended that CIPP be used primarily as an option to extend the life of a pipe that has no penetrating deterioration or at least no appreaciable soil loss, or for applications with limited access. CIPP is not recommended in cases where soil loss is substantial or indeterminate. Provide CIPP liner material manufactured in accordance with ASTM F1743 or ASTM F2019. Protect liners that conform to ASTM F2019 from UV exposure over the lifetime of the liner material.

2.2.5 Sprayed-In-Place Pipe (SIPP)

It is recommended that SIPP be used primarily as an option to extend the life of a pipe that has no penetrating deterioration or at least no appreaciable soil loss, or for applications with limited access. SIPP is not recommended, and may be prohibited, in cases where soil loss is substantial or indeterminate. Provide liner material manufactured in accordance with ASTM F3190ASTM F3182. Liners that contain polyurea or polyurethanes with methylene diphenyl diisocynate contain isocyanates and are prohibited.

2.2.6 UV Protection

For all slip liner pipes constructed of materials that are not UV stabilized that will be exposed to UV light, apply receive a field-applied coating on the end and interior surface of the pipe to resist deterioration from ultraviolet radiation. Apply the UV protective coating (white or light colored preferred) from the cut end of the pipe to a distance inside the pipe equal to two times the inside diameter of the liner pipe. Touch up nicks, scratches and minor abrasions to the coating 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 pipe manufacturer's published recommendations, using the more stringent of the two when conflicting. If the chosen pipe liner cannot meet the minimum factor of safety against bending, buckling or crushing on its own, then a structural grout must be used so the combination of these two elements can achieve the minimum factor of safety requirements.

2.3.2 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 shrinkage, set time, and reduce segregation. Do not use biodegradable admixtures.

2.3.2.4 Compressive Strength

2.3.2.4.1 Structural Grout

Use the grout 28-day compressive strength determined necessary for the pipe and grout composite design.

2.3.2.4.2 Non-structural Grout

No minimum compressive strength has been assigned for non-structural grouts.

2.3.2.5 Consideration for Mix Design

Design a grout mix and installation procedure to completely fill the annular space based upon, but not restricted to the list below, such that the slip liner pipe will not float (either by external restraint or internal weighting). Maintain an appropriate viscosity based on the maximum distance of flow required 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. Volume of annular void

b. Minimum strength to achieve the design requirements as stated herein

c. Retarder admixture for extended placement times

d. Shrinkage-reducing admixture to limit shrinkage to 1 percent by volume

e. Distance between grout injection ports

f. 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. 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]. Provide equipment capable of mixing the grout at densities required for the

approved procedures and 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. Provide pressure gauges that are suitable for use in a grouting environment and have a working range between 1.5 and 2.0 times the maximum 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 through the bulkhead 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 increase in viscosity occurs.

b. Non-structural Grout: Provide Grout Trial Mix Test Results with viscosity, density,and estimated initial set time to be used for subsequent lift placement timing. Also provide the grout working time before a 15 percent increase in density or viscosity occurs.

2.3.4 Bulkhead Concrete

Design a dry-pack concrete mix to form a bulkhead at each end of the pipe to retain the annular grout. Submit the bulkhead mix design for approval. Low slump concrete must consist of cement, fine and coarse aggregate, water, and an air-entraining admixture. Thoroughly compact concrete 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 must be above 4 degrees C 40 degrees F during placement.

PART 3 EXECUTION

3.1 PREPARATION AND INSPECTION

The Contracting Officer is not responsible for and makes no guarantees regarding the information, data, and physical condition of underground facilities or existing pipe[s]. 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 to the USACE for approval 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

Use remote CCTV inspections for small diameter or unsafe pipes, but walk-through inspections with digital photography are preferred over remote video inspections for pipes large enough and safe to enter when confined space entry procedures are followed. 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 ordering supplies or performing work in these areas.

### 3.1.2 Water Control

Submit the proposed means and methods as required to dewater the work area and divert flowing water around the work area, including berm dimensions, bypass pumping requirements (pump size as well as diameter and length of lines), and a dewatering plan, so that the work area remains satisfactorily dewatered to facilitate inspections, installation of the liner pipes, and placement of the grout.

### 3.1.3 Host Pipe Cleaning

Cleaning the host pipe is required prior to final visual inspection and installation of the slip liner pipe, but the host pipe should be visually inspected (by man-entry or CCTV camera) prior to cleaning to identify any areas of concern for the cleaning process (penetrating corrosion exposing erodable backfill or heavily corroded areas that may excessively delaminate during cleaning) where there's a potential to damage the pipe or the surrounding soil. Cleaning constitutes removal of all loose debris (soil, rocks, trash, etc.), roots, 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. If the integrity of the host pipe is suspect, a test section should be cleaned and re-inspected to see if damage to the pipe has occurred. 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.

### 3.1.4 Insertion and Pulling of Mandrel

Prior to insertion of the segmental liner pipe segments, pull a properly sized mandrel through the host pipe to check for adequate clearances prior to submitting the full materials order. Provide a properly sized mandrel with an outside diameter at least 2.54 centimeters2 inches greater than the slip liner pipe, having a length no less than the segment length of the liner pipe, and having a stiffness equal to or greater than that of the slip liner pipe. Provide a mandrel no less than 3 meters10 feet long for host pipes receiving a spiral-wound PVC liner. Any segment of slip liner pipe used as a mandrel is prohibited from being used as a permanent slip liner pipe. If the host pipe fails to allow the mandrel to pass, the rehabilitation method will have to be redesigned.

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**NOTE: The redesign could include a smaller liner pipe diameter (as long as the conveyance minimum is met) or the use of non-segmental liners such as CIPP, fold-and-form, or spray on liners (assuming the strength minimum is met by themselves since grout cannot be used with these liners).**

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## 3.2 EXCAVATION

The installation of a liner pipe is anticipated to only use existing

points of entry such as headwalls, manholes, and gatewells, but there may be a need in unusual circumstances to gain access to the host pipe through limited excavations along its length. Justify the need to excavate along the length of the host pipe in writing and submit to the Contracting Officer for approval. Any excavation will be limited in scope to only what is absolutely necessary to slip line the host pipe. 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. Point repairs, deemed necessary at any location on the existing pipeline prior to slip lining must be approved by the Contracting Officer prior to start of work.

b. Plug lateral lines according to the details submitted in the work plan. 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, trimmed, and sealed to a neat, clean opening concentric with the connection pipe in a manner that provides water tight seals on both ends of the reconnection (between the liner pipe and the connection pipe and between the connection pipe and the existing lateral line). This will require precise measurements from the bulkhead to the lateral connection and careful trimming to prevent removing material outside the connection area.

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

d. Provide maximum and minimum lay lengths in accordance with manufacturer's requirements and any constraints based on work limits [as prescribed by the Contracting Officer].

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

f. Use only sub-aqueous lubricants approved by the pipe manufacturer.

g. Correct conditions that would either prevent insertion of or cause unacceptable damage to the liner pipe during insertion, such as bulges or jagged edges protruding beyond the expected limits of the annular space.

h. 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. Make reasonable attempts 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.

i. Construct all blocking, if used, of inert, non-ferrous material, and install in accordance with manufacturer's recommendations.

j. 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.

k. 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.

l. The grout must achieve 'initial set' before a succeeding grout lift can be placed so the additional vertical load does not transmit additional lateral load to the pipe.

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

n. 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.

3.3.2 Machine Spiral Wound PVC Pipe (Excluding close-fit)

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 stringent of the three governs.

b. No mechanical pulling or pushing force (of the liner pipe (such as with a backhoe bucket or winch), other than that applied by the purpose-built installation machine, is allowed.

c. In all instances, insert the liner pipe as a fixed diameter with no subsequent expansion or contraction allowed.

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 governs.

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, constructing the bulkheads, or grouting the annulus. Inject grout according to the work plan so that the thermal limit is not exceeded and the pipe does not become buoyant.

c. Reconnection of lateral lines is accomplished using relatively short pieces of pipe of the same type of HDPE material used to slip line the main pipe and of a proper diameter to fit the lateral line such that grouting the annular space will not enter the lateral line. Extrusion welding is required to mate the lateral line stub to the main slip lining pipe.

d. Provide slip liner pipe 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 must be de-burred and free of defects.

e. Join sections of slip liner pipe and insert 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. Heating of the joints is allowed in cold weather to facilitate joining.

### 3.3.4 Glass Fiber-Reinforced Plastic Pipe

Install Glass Fiber-Reinforced Plastic Liner Pipe to the most restrictive requirements of ASTM D3839 or the manufacturer's recommendations.

### 3.3.5 Cured-In-Place Pipe

Follow the manufacturer's recommendations on the medium used to cure the liner (i.e. water, steam, or UV) and note special considerations regarding temperature, transport, and removal of the medium. Perform surface preparation of the host pipe according to the manufacturer's recommendations to ensure adhesion between the liner material and host pipe.

### 3.3.6 Sprayed-In-Place Pipe

Apply liner material radially onto the interior wall of the host pipe either mechanically or manually according to the manufacturer's requirements, including the necessary degree of cleanliness of the host pipe surface. Seamlessly apply lining material with no surface voids or ridges. Monitor viscosity and liner thickness closely to apply a uniform thickness throughout the host pipe.

### 3.3.7 Bulkheads for Annulus Grouting

a. Install the upstream bulkhead followed by the downstream bulkhead (to reduce the chance of collecting water within the host pipe) after waiting at least 24 hours between the minimum 24-hour and maximum 72-hour wait period after insertion of the liner pipe. Provide a bulkhead with a minimum thickness of 300 mm 1 foot, or the thickness of the headwall, whichever is greater.

b. Provide a sufficient number of staggered-length grout tubes so that the anticipated flow distance of the grout based on its viscosity can run the distance between the bulkheads before reaching initial set.

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

d. Place vent holes at the crown and the invert in the downstream bulkhead. Place an access hole, sized to facilitate the method of grout input and an air vent 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. Hand-finish the bulkheads to a professional quality appearance. After a curing period and pressure washing of the headwalls, apply a Soluble Reactive Silicate Concrete Treatment Product over the entire headwall surface, including the bulkheads.

3.3.8 Annulus Grouting

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.

c. Place annulus grout in lifts, as calculated and provided as a preconstruction submittal, to avoid floating of the liner and to ensure a uniform grout thickness.

d. A gauged grout pressure at the pipe exceeding that of the pipe manufacturer's recommendation or 35 kPa 5 psi, whichever is less, is not permitted. 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 injection holes from the surface to facilitate grouting is prohibited.

g. Continue injection of grout until the estimated volume of grout has been injected, as measured at the pump and the exhausted grout recovered at each vent is between 85 and 115 percent of the density of the freshly injected grout, or as otherwise approved by the Contracting Officer.

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

i. During cold weather grouting (0-5 degrees C 32-40 degrees F) the grout mix must be 15 degrees C 60 degrees F or higher at the time of pumping. Use concrete blankets for a period of not less than seven days over areas of the levee behind the headwalls where the minimum cover above the frost line is not met. The use of an internal heater is permitted if it does not exceed the pipe's maximum localized temperature for the first 24 hours after grouting.

j. Provide annular space grout test reports for approval.

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 expense. Materials left in place, but not meeting these Specifications, will be paid for at a reduced price.

3.4.2 Pressure Testing

If the liner pipe will experience gravity flow only and the annular space between it and the host pipe is grouted full, pressure testing the joints is not required unless the video inspection reveals concerning anomalies that may indicate a compromised joint.

3.4.3 Grout Testing

3.4.3.1 Density

Field measure grout density in accordance with ASTM C138/C138M no less than twice per batch during grouting. Reevaluate grout densities exceeding the design density by more than 48 kg/cubic meter 3 lb/cubic foot for flow and flotation before placement continues, otherwise reject.

3.4.3.2 Compressive Strength

Provide grout with a minimum penetration resistance of 1725 kPa 250 psi when tested in accordance with ASTM C403/C403M before a succeeding grout lift can be placed. Engage the services of an independent, ASTM/AASHTO accredited testing laboratory to collect and test specimens associated with the strength requirements of this Section.

3.4.3.2.1 Structural Grout

a. Collect, transport, cure, test and report samples in accordance with ASTM C942/C942M, except as stated below.

b. Collect and test specimens based on the more restrictive of the following criteria:

(1) One specimen (a specimen being one 3-gang mold) for each grouting event for each pipe collected at approximately the mid-point of the grouting operations. Collect a specimen for each time period testing desired prior to the 28-day test.

(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 collected and performed at the Contractor's discretion. The Contracting Officer will determine the course of action, which may require the complete removal of the liner and grout, if samples do not meet the minimum required strength.

3.4.3.2.2 Non-structural Grout

Collect, transport, cure, test and report samples in accordance with the applicable ASTM for viscosity (ASTM C939/C939M), density (ASTM C138/C138M ), and 24-hour penetration resistance (ASTM C403/C403M). Compression testing is not required for non-structural grout.

### 3.4.4 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. Inspect small or unsafe pipes using CCTV. Submit the Post-Installation CCTV Recordings and Report Logs and/or Post-Installation Digital Photographs and Report Logs.

a. The Contracting Officer will determine if infiltration of ground water or annular grout through the liner pipe will be a basis for non-acceptance or if a repair will be satisfactory.

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

#### 3.4.4.1 Defects

Correct all defects discovered during the post-installation inspection 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, inspect the affected pipe segments 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 must be borne by the Contractor.

#### 3.4.4.2 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 --