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Preparing Activity: USACE Superseding
UFGS-33 40 00 (February 2010)

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

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

SECTION 33 40 00

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**11/21**

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SECTION 33 40 00

STORMWATER UTILITIES
**11/21**

**NOTE: This guide specification covers the requirements for storm drainage piping systems using concrete, clay, steel, ductile iron, aluminum, polyvinyl chloride (PVC), polyethylene (PE), polypropylene (PP) pipe and steel reinforced polyethylene (SRPE) pipe.**

**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).**

PART 1 GENERAL

**NOTE: On the project drawing, show:**

**1. Plan and location of all new pipelines, including type of service and size of pipe.**

**2. Location, size, and type of service of existing connecting, intersecting, or adjacent pipelines and other utilities.**

**3. Paved areas and railroads which pass over new pipelines.**

**4. Profile, where necessary to show unusual conditions.**

**5. Invert elevations at beginning and end of pipelines and at manholes or similar structures.**

**6. Class or strength of pipe and limits for same where class or strength will be different for different sections of pipeline. Provide shape requirements if different shapes are available.**

**7. Design details for pertinent manholes, catch basins, curb inlets, and head walls.**

**8. Storm drainage lines and culverts required to be watertight.**

**9. Bedding conditions, where different from those specified and location of cradle(s), when cradle is required if not covered under the appropriate specifications.**

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## 1.1 UNIT PRICES

**********

**NOTE: Delete this paragraph when the work specified is included in a lump sum contract price.**

**Separate bid may be required for each item for the construction of the various sizes of pipe culverts and storm drains and individual miscellaneous drainage structures, including all excavation, materials, backfilling, etc., for the completed work.**

**If separate bid items are used for the excavation, this fact should be clearly stated in the specifications and bid form, indicating that payment is to be made separately for earth excavation, rock excavation, borrow excavation, or other items that otherwise might be construed as the basis for a claim by the Contractor. Unit prices for rock excavation should be independent of, and not in addition to, the unit bid price for common excavation, unless so specified and so stated in the bid form.**

**********

### 1.1.1 Pipe Culverts and Storm Drains

The length of pipe installed will be measured along the centerlines of the pipe from end to end of pipe without deductions for diameter of manholes. Pipe will be paid for at the contract unit price for the number of linear meters feet of culverts or storm drains placed in the accepted work.

### 1.1.2 Box Culverts

The length of box culvert installed will be measured along the centerline

of the box from end to end of the box culvert. Box Culvert will be paid for at the contract unit price for the number of linear meters feet of box culverts placed in the accepted work.

1.1.3 Storm Drainage Structures

**********
**NOTE: Fill brackets with depth requirements.**
**********

The quantity of manholes and inlets will be measured as the total number of manholes and inlets of the various types of construction, complete with frames and gratings or covers and, where indicated, with fixed side-rail ladders, constructed to the depth of [_____] meters feet in the accepted work. The depth of manholes and inlets will be measured from the top of grating or cover to invert of outlet pipe. Manholes and inlets constructed to depths greater than the depth specified above will be paid for as units at the contract unit price for manholes and inlets, plus an additional amount per linear meter foot for the measured depth beyond a depth of [_____] meters feet.

1.1.4 Walls and Headwalls

Walls and headwalls will be measured by the number of cubic meters yards of reinforced concrete, plain concrete, or masonry used in the construction of the walls and headwalls. Wall and headwalls will be paid for at the contract unit price for the number of walls and headwalls constructed in the completed work.

1.1.5 Flared End Sections

Flared end sections will be measured by the unit. Flared end sections will be paid for at the contract unit price for the various sizes in the accepted work.

1.1.6 Sheeting and Bracing

Payment will be made for that sheeting and bracing ordered to be left in place, based on the number of square meters feet of sheeting and bracing remaining below the surface of the ground.

1.1.7 Rock Excavation

**********
**NOTE: Reference should be made to other sections of the project specifications, as applicable, or pertinent requirements may be included in this section.**
**********

Payment will be made for the number of cubic meters yards of material acceptably excavated, as specified and defined as rock excavation in Section 31 00 00 EARTHWORK, measured in the original position, and computed by allowing actual width of rock excavation with the following limitations: maximum rock excavation width, 750 mm 30 inches for pipe of 300 mm 12 inch or less nominal diameter; maximum rock excavation width, 400 mm 16 inches greater than outside diameter of pipe of more than 300 mm 12 inch nominal diameter. Measurement will include authorized overdepth excavation. Payment will also include all necessary drilling and

blasting, and all incidentals necessary for satisfactory excavation and disposal of authorized rock excavation. No separate payment will be made for backfill material required to replace rock excavation; include this cost in the unit price bid per cubic meter yard for rock excavation. In rock excavation for manholes and other appurtenances, 300 mm 1 foot will be allowed outside the wall lines of the structures.

### 1.1.8 Backfill Replacing Unstable Material

Payment will be made for the number of cubic meters yards of select granular material required to replace unstable material for foundations under pipes or drainage structures, which will constitute full compensation for this backfill material, including removal and disposal of unstable material and all excavating, hauling, placing, compacting, and all incidentals necessary to complete the construction of the foundation satisfactorily.

### 1.1.9 Concrete Ditch Lining

Payment will be made for the number of linear meters feet of concrete ditch lining including any steel reinforcing accepted in the completed work measured along the centerline of the ditch.

## 1.2 REFERENCES

**********

**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.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

| | |
|---|---|
| AASHTO HB-17 | (2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges |
| AASHTO M 43 | (2005; R 2018) Standard Specification for Sizes of Aggregate for Road and Bridge |

| | |
|---|---|
| | Construction |
| AASHTO M 167M/M 167 | (2017; R 2021) Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches |
| AASHTO M 190 | (2004; R 2019) Standard Specification for Asphalt-Coated Corrugated Metal Culvert Pipe and Pipe Arches |
| AASHTO M 219 | (1992; R 2021) Standard Specification for Corrugated Aluminum Alloy Structural Plate for Field-Bolted Pipe, Pipe-Arches, and Arches |
| AASHTO M 243 | (1996; R 2021) Standard Specification for Field-Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches |
| AASHTO M 288 | (2021) Standard Specification for Geosynthetic Specification for Highway Applications |
| AASHTO M 294 | (2021) Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A48/A48M | (2003; R 2021) Standard Specification for Gray Iron Castings |
| ASTM A123/A123M | (2017) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products |
| ASTM A536 | (1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings |
| ASTM A716 | (2018; R 2022) Standard Specification for Ductile Iron Culvert Pipe |
| ASTM A760/A760M | (2015, R 2020) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains |
| ASTM A798/A798M | (2022) Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications |
| ASTM A807/A807M | (2019) Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications |
| ASTM A929/A929M | (2018) Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe |

| | |
|---|---|
| ASTM A1011/A1011M | (2023) Standard Specification for Steel Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength |
| ASTM B26/B26M | (2018; E 2018) Standard Specification for Aluminum-Alloy Sand Castings |
| ASTM B745/B745M | (2015; R 2021) Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains |
| ASTM C12 | (2022) Standard Practice for Installing Vitrified Clay Pipe Lines |
| ASTM C14 | (2020) Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe |
| ASTM C14M | (2020) Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe (Metric) |
| ASTM C32 | (2013; R 2017) Standard Specification for Sewer and Manhole Brick (Made from Clay or Shale) |
| ASTM C55 | (2022) Standard Specification for Concrete Building Brick |
| ASTM C62 | (2017) Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale) |
| ASTM C76 | (2022a) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe |
| ASTM C76M | (2022a) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric) |
| ASTM C139 | (2022) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes |
| ASTM C231/C231M | (2022) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method |
| ASTM C270 | (2019a; E 2019) Standard Specification for Mortar for Unit Masonry |
| ASTM C425 | (2021) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings |

| | |
|---|---|
| ASTM C443 | (2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets |
| ASTM C443M | (2021) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric) |
| ASTM C478/C478M | (2022) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections |
| ASTM C506 | (2022a) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe |
| ASTM C506M | (2022a) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe (Metric) |
| ASTM C507 | (2022) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe |
| ASTM C507M | (2022) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe (Metric) |
| ASTM C655 | (2019a) Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe |
| ASTM C655M | (2019a) Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe (Metric) |
| ASTM C700 | (2018; R 2022) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated |
| ASTM C828 | (2023) Standard Test Method for Low-Pressure Air Test of Vitrified Clay Pipe Lines |
| ASTM C923/C923M | (2020) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals |
| ASTM C990 | (2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants |
| ASTM C990M | (2009; R 2019) Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants (Metric) |

| | |
|---|---|
| ASTM C1103 | (2022) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines |
| ASTM C1103M | (2019) Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric) |
| ASTM C1433 | (2020) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers |
| ASTM C1433M | (2022) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers (Metric) |
| ASTM D1056 | (2020) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber |
| ASTM D1171 | (2018) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking Outdoors (Triangular Specimens) |
| ASTM D1751 | (2018) Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types) |
| ASTM D1752 | (2018) Standard Specification for Preformed Sponge Rubber, Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction |
| ASTM D2321 | (2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications |
| ASTM D2487 | (2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System) |
| ASTM D2564 | (2020) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems |
| ASTM D3034 | (2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings |
| ASTM D3212 | (2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals |
| ASTM F477 | (2014; R 2021) Standard Specification for |

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|---|---|
| | Elastomeric Seals (Gaskets) for Joining Plastic Pipe |
| ASTM F679 | (2016) Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings |
| ASTM F714 | (2022) Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter |
| ASTM F794 | (2021) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter |
| ASTM F894 | (2019) Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe |
| ASTM F949 | (2020) Standard Specification for Poly(Vinyl Chloride) (PVC) Corrugated Sewer Pipe with a Smooth Interior and Fittings |
| ASTM F1417 | (2011a; E 2020) Standard Practice for Installation Acceptance of Plastic Non-pressure Sewer Lines Using Low-Pressure Air |
| ASTM F2418 | (2019) Standard Specification for Polypropylene (PP) Corrugated Wall Stormwater Collection Chambers |
| ASTM F2562/F2562M | (2015; R 2019) Specification for Steel Reinforced Thermoplastic Ribbed Pipe and Fittings for Non-Pressure Drainage and Sewerage |
| ASTM F2620 | (2020a; E 2021) Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings |
| ASTM F2764/F2764M | (2023) Standard Specification for 6 to 60 in. [150 to 1500 mm] Polypropylene (PP) Corrugated Double and Triple Wall Pipe and Fittings for Non-Pressure Sanitary Sewer Applications |
| ASTM F2881/F2881M | (2021; E 2021) Standard Specification for 12 to 60 in. (300 to 1500 mm) Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications |
| ASTM F2922 | (2013; R 2018) Standard Specification for Polyethylene (PE) Corrugated Wall Stormwater Collection Chambers |

ASTM F3219 (2019) Standard Specification for 3 to 30 in. (75 to 750 mm) Polypropylene (PP) Corrugated Single Wall Pipe and Fittings

## 1.3 SUBMITTALS

**********

**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.**

**********

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-06 Test Reports

Leakage Test; G[, [_____]]

SD-07 Certificates

Hydrostatic Test on Watertight Joints; G[, [_____]]

Frame and Cover or Gratings; G[, [_____]]

SD-08 Manufacturer's Instructions

Placing Pipe and Box Culvert; G[, [_____]]

SD-11 Closeout Submittals

Post-Installation Inspection Report; G[, [_____]]

LID Verification Report; G[, [_____]]

## 1.4 DELIVERY, STORAGE, AND HANDLING

### 1.4.1 Delivery and Storage

Inspect materials delivered to site for damage and unload and store materials with minimumal handling. Do not store materials directly on the ground. Keep the inside of pipes and fittings free of dirt and debris. Before, during, and after installation, protect plastic pipe and fittings from any environment that would result in damage or deterioration to the material. Keep a copy of the manufacturer's instructions available at the construction site at all times and follow these instructions unless directed otherwise by the Contracting Officer. Store solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe in accordance with the manufacturer's recommendations and discard if the storage period exceeds the recommended shelf life. Discard solvents in use when the recommended pot life is exceeded.

### 1.4.2 Handling

Handle materials in a manner that ensures delivery to the trench in sound, undamaged condition. Carry pipe to the trench.

# PART 2 PRODUCTS

## 2.1 PIPE FOR CULVERTS AND STORM DRAINS

**********

**NOTE: Where the type of pipe is to be the Contractor's option, the types (with size, class, shape, strength, sheet thickness, or gauge) that are acceptable should be listed. The inapplicable types of pipe will be deleted. In specifying plastic, clay, and concrete pipe or aluminum alloy and steel pipe for culverts and storm drains, pipe of comparable strength or stiffness for the various sizes should be specified.**

**Pipe materials which are known to be unsuitable for local conditions (i.e. corrosion, etc.) should not be permitted for the project. However, consideration should be given to the use of more effective protective coatings where economically feasible.**

**In areas where problems with root penetration are anticipated, specify pipe which has the kind of joint which will successfully resist root penetration. Generally speaking, the more watertight the joint, the greater will be the resistance to root penetration. Rubber-gasketed and compression-type joints are considered to give the best performance for this application.**

**American Society of Civil Engineers (ASCE) Manual of Practice No. 37, "Design and Construction of Sanitary and Storm Sewers," contains methods of calculation for structural requirements of pipe; from these, the required strengths for pipe of various materials may determined. Investigate external loads, including earth loads, truck loads, seismic loads, and impact, in the design stage of the project. Give special attention, in the design stage of the project, to plastic pipe materials, particularly with respect to superimposed external loads which could cause excessive deflection of the pipe. The degree of sidefill compaction should be considered realistically, particularly in marginal cases. See also the appendices to ASTM D2321.**

**UFC 3-201-01 does not allow plastic storm drain pipe to be used under any type of airfield pavement except for subsurface water collection and disposal.**

**********

Pipe sizes for culverts and storm drains are indicated on the drawings.

2.1.1 Concrete Pipe

**********

**NOTE: The various classes designate different D-loads. D-load is defined as the minimum required three-edge test load on a pipe to produce a 0.01 inch crack and/or ultimate failure in pounds per linear foot per foot (no metric definition) of inside diameter.**

**Where sulfate-resistant pipe is required and concrete pipe is to be an option, specify Type II or Type V cement. Specify Type II (moderate sulfate resisting) cement when water-soluble sulfates (as S04) in the soil are in the range of 0.1 to 0.2 percent and, for water, are in the range of 150 to 1,000 parts per million. Specify Type V (sulfate**

**resisting) cement when soils contain in excess of 0.2 percent water-soluble sulfate and water samples contain in excess of 1,000 parts per million. In areas where reactive aggregates are known to occur, specify low alkali cement.**

**Pipe sizes 300 mm (12 inch) diameter through 600 mm (24 inch) diameter may be either reinforced or nonreinforced concrete pipe.**

**********

2.1.1.1 Reinforced Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C76M ASTM C76, Class [I] [II] [III] [IV] [V] [as indicated], or ASTM C655M ASTM C655, [_____] D-Load [as indicated].

2.1.1.2 Reinforced Arch Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C506M ASTM C506, Class [A-II] [A-III] [A-IV] [as indicated].

2.1.1.3 Reinforced Elliptical Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C507M ASTM C507, Class [HE-A] [HE-I] [HE-II] [HE-III] [HE-IV] [as indicated] for horizontal elliptical pipe and Class [VE-II] [VE-III] [VE-IV] [VE-V] [VE-VI] [as indicated] for vertical elliptical pipe.

2.1.1.4 Nonreinforced Culvert and Storm Drain Pipe

Manufactured in accordance with and conforming to ASTM C14M ASTM C14, Class [1] [2] [3] [as indicated].

2.1.2 Clay Pipe

**********

**NOTE: Specify "bell-and-spigot piping only" in areas where corrosion problems may be anticipated with the stainless steel parts of the couplings used for plain-end piping.**

**********

ASTM C700, [standard] [extra] strength, [bell-and-spigot piping only].

2.1.3 Corrugated Steel Pipe

**********

**NOTE: Corrugated steel pipe is manufactured from steel sheet with corrugations consisting of either cicular arcs and alternating tangent segments (arc and tangent) or alternating rectangular ribs and flat segments (spiral rib). Not all corrugated steel pipe manufacter's fabricate spiral rib pipe. In the past, pipe was fabricated by riveting sheets together to form pipe with annular corrugations. Today, most corrugated steel pipe is produced on a machine that forms helical corrugations. The steel sheets are joined together by either a continuous**

**lock seam or welded seam.**

**The roughness coeffient of pipe with annular corrugations or helical spiral rib corrugations does not vary with increasing pipe diameter. The roughness coefficient of pipe with helical arc and tangent corrugations increases with increasing pipe diameter. Pipe with helical corrugations has a lower roughness coefficient than pipe with annular corrugations. Corrugated pipe with helical corrugations should typically be specified for most projects.**

**Type I pipe has a full circular cross section and is fabricated with corrugated sheet. Type IR pipe has a full circular cross section and is fabricated from smooth sheet with helical ribs. Type II pipe is fabricated from Type I pipe that has been reformed into a pipe-arch. Type IIR pipe is fabricated from Type IR pipe that has been reformed into a pipe-arch.**

**The service life of a corrugated steel pipe is dependent on the pipe material and environmental conditions. The pipe material can vary with steel sheet thickness, metallic coating and non-metallic coating and paving. The available sheet thickness varies with the pipe diameter. Some manufacturers have the equipment to fabricate pipe using a heavier gage sheet than others. Typically either a zinc or aluminum (Type 2) metallic coating is specified. Pipe fabricated from corrugated steel sheet with a polymer coating (polymer precoated) can also be specified. The additional service life provided by asphalt coating and paving varies. A description of available coatings and durability guidelines is included in the National Corrugated Steel Pipe Association (NCSPA) publication "Modern Sewer Design".**

**To promote competitive bidding, polymer precoated pipe should generally be specified as an option if a non-metallic coating is required to provide the desired service life. Many pipe manufacturer's produce polymer precoated pipe in lieu of bituminous coated pipe. Polymer precoating provides greater additional service life than bituminous coating. Some severe environments may cause corrosion problems to accessory items such as rivets or coupling band hardware that do not have a polymer coating.**

**Corrugated steel piping with aramid fiber composite coating is recommended for use where severely corrosive conditions, such as highly acidic soils, tidal drainage, mine drainage, and certain industrial wastes, are present.**

**Other corrugation sizes are available and may be specified.**

**Sheet thickness of pipes should be indicated on the drawings. Select sheet thickness for each pipe that will support imposed loads and provide adequate protection from corrosion. The maximum thickness of metallic coated steel sheet that can be used to fabricated pipe will vary depending on the pipe diameter.**

**Perforated Type III pipe can be specified where pipe is used as an underdrain for underground disposal of water.**

**********

Provide Type [I] [and] [II] [or] [IR] [and] [IIR] corrugated steel pipe conforming to ASTM A760/A760M with [zinc] [or] [aluminum (Type 2)] coating. [Provide Type [I] [II] pipe with helical 68 by 13 mm 2-2/3 by 1/2 inch corrugations.] [Provide Type [IR] [IIR] pipe with helical 19 by 19 by 190 mm 3/4 by 3/4 by 7-1/2 inch corrugations.]

**********

**NOTE: Coatings, linings and paving can be applied to zinc or aluminum (Type 2) coated corrugated steel pipe to provide additional service life. Coatings, linings and paving are applied after fabrication of the pipe.**

**AASHTO M 190 covers four types of asphalt-coated corrugated metal pipe as follows:**

**Type A - Fully Asphalt-Coated**
**Type B - Half Asphalt-Coated with Paved-Invert**
**Type C - Fully Asphalt-Coated and Paved-Invert**
**Type D - Fully Asphalt-Coated and 100 Percent Paved or Lined**

**********

[Provide pipe that is fully asphalt coated [and [part] [fully] asphalt paved] conforming to AASHTO M 190 Type [A] [C] [D].] [Provide pipe that is polymer precoated in accordance with ASTM A 762/A 762M with pipe fabricated from ASTM A 742/A 742M Grade 10/10 polymer precoated sheet.]

2.1.4 Corrugated Aluminum Pipe

**********

**NOTE: Corrugated aluminum pipe has shown satisfactory corrosion resistance in clean granular materials even when seawater is present. However, corrugated aluminum pipe should not be used in highly acid (pH below 4) or highly alkaline (pH**

**above 9) soils, or in organic silts and clays, identified as Types OH and OL in the Soil Classification Chart, ASTM D2487. This pipe should also not be used where it will be in contact with other metals or in metallic deposits.**

**Type I pipe has a full circular cross section and is fabricated with corrugated sheet. Type IR pipe has a full circular cross section and is fabricated from smooth sheet with helical ribs. Type II pipe is fabricated from Type I pipe that has been reformed into a pipe-arch. Type IIR pipe is fabricated from Type IR pipe that has been reformed into a pipe-arch.**

**Other corrugation sizes are available and may be specified.**

**Sheet thickness of pipes should be indicated on the drawings.**

**Perforated Type III pipe can be specified where pipe is used as an underdrain for underground disposal of water.**

**********

Provide Type [I] [and] [II] [or] [IR] [and] [IIR] corrugated aluminum pipe conforming to ASTM B745/B745M. [Provide Type [I] [II] pipe with helical 68 by 13 mm 2-2/3 by 1/2 inch corrugations.] [Provide Type [IR] [IIR] pipe with helical 19 by 19 by 190 mm 3/4 by 3/4 by 7-1/2 inch corrugations.]

**********

**NOTE: Coatings, linings and paving can be applied to corrugated aluminum alloy pipe to provide additional service life. Coatings, linings and paving are applied after fabrication of the pipe.**

**AASHTO M 190 covers four types of asphalt-coated corrugated metal pipe as follows:**

**Type A - Fully Asphalt-Coated**
**Type B - Half Asphalt-Coated with Paved-Invert**
**Type C - Fully Asphalt-Coated and Paved-Invert**
**Type D - Fully Asphalt-Coated and 100 Percent Paved or Lined**

**********

[Provide pipe that is fully asphalt coated [and [part] [fully] asphalt paved] conforming to AASHTO M 190 Type [A] [C] [D].]

2.1.5 Structural Plate, Steel Pipe, Pipe Arches and Arches

**********

**NOTE: This paragraph includes options for providing a protective coating on the structural plate pipe. The designer will delete these options when protective coating is not a part of the project requirements. When protective coating on the structural-plate pipe is a project requirement, the designer will select the applicable option. Steel and aluminum pipe manufacturers state that it is impracticable in initial construction to provide a permanent paved invert of bituminous material in structural-plate corrugated steel and aluminum pipe.**

**Indicate the required sheet thickness of plates on the drawings.**

**********

Assembled with galvanized steel nuts and bolts, from galvanized corrugated steel plates conforming to AASHTO M 167M/M 167. [Provide pipe coating conforming to the requirements of [AASHTO M 190 Type A] [AASHTO M 243].]

2.1.6 Structural Plate, Aluminum Pipe, Pipe Arches and Arches

**********

**NOTE: Coordinate with paragraph Corrugated Steel Pipe and paragraph Structural Plate, Steel Pipe, Pipe Arches and Arches.**

**Indicate the required sheet thickness of plates on the drawings.**

**********

Assembled with either aluminum alloy, aluminum coated steel, stainless steel or zinc coated steel nuts and bolts. Provide nuts and bolts, and aluminum alloy plates conforming to AASHTO M 219. [Provide pipe coating conforming to the requirements of [AASHTO M 190, Type A] [AASHTO M 243].]

2.1.7 Ductile Iron Culvert Pipe

Provide ductile iron culvert pipe conforming to ASTM A716.

2.1.8 Poly Vinyl Chloride (PVC) Pipe

2.1.8.1 Type PSM PVC Pipe

ASTM D3034, maximum SDR 35.

2.1.8.2 Profile PVC Pipe

ASTM F794, Series 46.

2.1.8.3 Smooth Wall PVC Pipe

ASTM F679.

2.1.8.4 Corrugated PVC Pipe

**********
**NOTE: Perforated pipe can be specified where pipe is used as an underdrain for underground disposal of water.**
**********

ASTM F949.

2.1.9 Polyethylene (PE) Pipe

**********
**NOTE: For Navy projects, polyethylene pipe may only be used in non-traffic areas and beneath POV parking areas and must not be used beneath roads or heavy-duty military parking or hardstands.**
**********

2.1.9.1 Smooth Wall PE Pipe

ASTM F714, maximum DR of 21 for pipes 80 to 600 mm 3 to 24 inches in diameter and maximum DR of 26 for pipes 650 to 1200 mm 26 to 48 inches in diameter. Polyethylene compound material designation PE3608.

2.1.9.2 Corrugated PE Pipe

AASHTO M 294, Type S. Provide pipe walls having the following properties:

| Nominal Size (mm) (inch) | Minimum Wall Area (square mm/m) (square in/ft) | Minimum Moment of Inertia of Wall Section (mm to the 4th/mm) (in. to the 4th/in.) |
|---|---|---|
| 30012 | 32001.5 | 3900.024 |
| 37515 | 40001.91 | 8700.053 |
| 45018 | 49002.34 | 10200.062 |
| 60024 | 66003.14 | 19000.116 |
| 75030 | 83003.92 | 26700.163 |
| 90036 | 95004.50 | 36400.222 |
| 105042 | 99004.69 | 89000.543 |
| 120048 | 10,9005.15 | 89000.543 |
| 135054 | 12,0005.67 | 13,1100.800 |
| 150060 | 13,6506.45 | 13,1100.800 |

2.1.9.3 Profile Wall PE Pipe

ASTM F894, RSC 160. Provide pipe walls having the following properties:

| Nominal Size (mm) (inch) | Minimum Wall Area (square mm/m) (square in/ft) | Minimum Moment (mm to the 4th/mm) (in to the 4th/in) | |
|---|---|---|---|
| | | Cell Class 334433C | Cell Class 335434C |
| 45018 | 63002.96 | 8500.052 | 6200.038 |
| 52521 | 88004.15 | 11500.070 | 8400.051 |
| 60024 | 99004.66 | 13300.081 | 9700.059 |
| 67527 | 12,5005.91 | 20500.125 | 14900.091 |
| 75030 | 12,5005.91 | 20500.125 | 14900.091 |
| 82533 | 14,8006.99 | 26400.161 | 21600.132 |
| 90036 | 17,1007.81 | 33100.202 | 27000.165 |
| 105042 | 16,5008.08 | 45400.277 | 37200.227 |
| 120048 | 18,7008.82 | 55400.338 | 45400.277 |

2.1.10 Steel Reinforced Polyethylene (SRPE) Pipe

**********

**NOTE: Steel Reinforced Polyethylene Pipe is manufactured in 5 stiffness classes. The class of pipe should be specified or indicated on the drawings.**

**********

Provide SRPE pipe conforming to the requirements of ASTM F2562/F2562M, Class [___] [as indicated].

2.1.11 Polypropylene(PP) Pipe

**********

**NOTE: PP Pipe conforming to ASTM F2764/F2764M has a pipe stiffness of 320 KPA 46 psi for all diameters. The stiffness of PP Pipe conforming to ASTM F2881/F2881 varies with the diameter of the pipe. Pipe diameters range from 300 to 1,500 mm 12 to 60 inches.**

**Perforated pipe conforming to ASTM F2881/F2881M with Class II perforation patterns can be specified where pipe is used as an underdrain for underground disposal of water.**

**********

Provide double wall and triple wall pipe meeting the requirements of ASTM F2764/F2764M or ASTM F2881/F2881M, Class [I] [II].

## 2.2 PIPE JOINTS

**********

**NOTE: Watertight joints are typically specified in storm drains to prevent infiltration of water and fine-grained soil through joints when the water table is at or above the pipeline.**

**Watertight joints are required in pipes through levees in accordance with EM 1110-2-2902.**

**Delete sentence in brackets when watertight joints are not necessary.**

**********

[Provide joints that have been tested for and meet the requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS.]

### 2.2.1 Concrete Pipe

**********

**NOTE: Where watertightness is essential, specify only rubber gasket joints. Where waterightness is not required, allow either rubber gasket joints or joints with preformed flexible joint sealant.**

**See EM 1110-2-2902 for joint requirements for pipe through levees.**

**Rubber gaskets are not available for arch or elliptical pipe.**

**********

#### 2.2.1.1 Rubber Gasket Joints

Provide rubber gasket joints of a design and physical requirements conforming to ASTM C443M ASTM C443. [Provide rubber gaskets that meet the oil resistant gasket requirements of ASTM C443M ASTM C443.]

#### 2.2.1.2 Preformed Flexible Sealant Joints

Provide joints made with preformed flexible joint sealant conforming to ASTM C990M ASTM C990.

### 2.2.2 Clay Pipe

Provide joints made with factory-fabricated resilient materials conforming to ASTM C425.

### 2.2.3 Corrugated Steel and Aluminum Pipe

**********

**NOTE: The annular and partially corrugated bands with gaskets specified below should be capable of providing a watertight joint. Other jointing systems (soil tight, silt tight, leak resistant,**

**special design) as described in ASTM A760 can be specified when applicable.**

**When a specific joining system is necessary (band type and width, number and type of connectors, gasket type, etc.), the requirements should be specified and indicated on the drawings. See EM 1110-2-2902 for joint requirements for pipe through levees.**

**********

Factory reform each end of pipe with helical corrugations to create annular corrugations of the same dimensions as those in the pipe. Provide reformed ends with a width equal to at least half the width of the band being used. Join pipe using annular corrugated [or] [partially corrugated] coupling bands. Except as otherwise specified or indicated, provide annular corrugated [or] [partially corrugated] coupling bands including connectors and hardware conforming to [ASTM A760/A760M] [ ASTM B745/B745M]. Provide coupling bands with either rod and lug or angle-bolt type connectors.

2.2.3.1 Annular Corrugated Bands

**********

**NOTE: Specify Type 2A1 gasket material when resistance to the action of petroleum base oils is not required. Specify Type 2B3 gasket material when oil resistance is required.**

**********

Provide sleeve type gaskets made of approximately 9.5 mm 3/8 inch thick by 178 mm 7 inch minimum width closed cell, expanded synthetic rubber, fabricated in the form of a cylinder with a diameter approximately 10 percent less than the nominal pipe size with annular corrugated type bands. Provide sleeve type gaskets that meet the requirements of ASTM D1056, Type 2 [A1] [B3] [_____], and have a quality retention rating of not less than 70 percent when tested for weather resistance by ozone chamber exposure, Method B of ASTM D1171

2.2.3.2 Partially Corrugated Bands

**********

**NOTE: Partially corrugated bands are intended for use with helically corrugated steel pipe with ends rerolled to a 68 mm 2-2/3 inch by 13 mm 1/2-inch corrugation.**

**********

Provide partially corrugated type bands with two O-ring gaskets and a sealant strip where the band ends overlap. Provide rubber O-ring gaskets that are 21 mm 13/16 inch in diameter for pipe diameters of 914 mm 36 inches or smaller and 22 mm 7/8 inch in diameter for larger pipe having 13 mm 1/2 inch deep end corrugation.

2.2.4 Ductile Iron Pipe

Provide push-on type joints with rubber gaskets.

2.2.5 PVC Plastic Pipe

Provide solvent cement or elastomeric gasket type joints in accordance with the specification for the pipe and as recommended by the pipe manufacturer. Use solvent cement conforming to ASTM D2564. Provide gaskets for elastomeric joints conforming to ASTM F477.

2.2.6 Smooth Wall PE Plastic Pipe

Join pipe using butt fusion method conforming to ASTM F2620. No offset in alignment between adjacent pipe ends is permitted.

2.2.7 Corrugated PE Plastic Pipe

Provide [soil] [silt] [water] tight joints conforming to the requirements in AASHTO M 294. [Make water tight joints using a PE coupling and rubber gaskets as recommended by the pipe manufacturer. Provide rubber gaskets conforming to ASTM F477.]

2.2.8 Profile Wall PE Pipe

Provide gasketed or thermal weld type with integral bell joints in accordance with ASTM F894.

2.2.9 Steel Reinforced Polyethylene (SRPE) Pipe

Provide joints meeting the requirements of ASTM D3212.

2.2.10 Dual Wall and Triple Wall PP Pipe

Provide two gaskets conforming to ASTM F477 on the spigot. Gaskets must be installed by the pipe manufacturer and be covered with a removable, protective wrap to ensure the gaskets are free from debris. Use a joint lubricant available from the manufacturer on the gasket and bell during assembly. [ASTM F2881/F2881M for 300 to 1500 mm 12 to 60 inches pipe][ ASTM F3219 for 300 to 750 mm 12 to 30 inches pipe][ASTM F2764/F2764M for 750 to 1500 mm 30 to 60 inches pipe] diameters must have a reinforced bell with a polymer composite band installed by the manufacturer. Provide fittings conforming to [ASTM F2881/F2881M] [ASTM F3219] [ASTM F2764/F2764M ]. Utilize a spun-on, welded or integral bell and spigot with gaskets meeting ASTM F477 for bell and spigot connections.

2.3 PRECAST REINFORCED CONCRETE BOX CULVERT

Manufacture precast reinforced concrete box culverts in accordance with and conforming to ASTM C1433M ASTM C1433.

2.4 THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS

**********

**NOTE: Chambers must be installed as a system that includes, but is not limited to, rows of chambers, end caps, manifold piping, foundation stone, embedment stone, geotextile fabric, and a maintenance system.**

**Structural design of chambers must conform to ASTM F2787.**

**For Navy projects, thermoplastic collection chambers may only be used in non-traffic areas and beneath POV parking areas and must not be used beneath roads or heavy-duty military parking or hardstands.**
**********

Provide [perforated] [non-perforated] themoplastic corrugated wall stormwater collection chambers. Provide [polyethylene chambers conforming to ASTM F2922] [or] [polypropylene chambers conforming to ASTM F2418]. Provide chamber classification as indicated on the drawings.

## 2.5 UNDERGROUND STORMWATER RETENTION/DETENTION SYSTEM

**********
**NOTE: Underground stormwater retention/detention systems can be constructed using pipes, collection chambers, concrete vaults/arches/chambers, stackable modular structures, etc.**

**Delete inapplicable gradation sizes.**
**********

Provide an underground stormwater retention/detention system that includes [thermoplastic corrugated wall stormwater collection chambers and corrugated PE pipe manifolds] [corrugated PE pipe] [corrugated steel pipe] as indicated. Provide foundation and embedment stone that is washed, crushed and angular conforming to AASHTO M 43 size 3, 357, 4, 467, 5, 56, or 57. Provide initial fill material conforming to AASHTO M 43 size 3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9 or 10. Provide geotextile conforming to AASHTO M 288.

## 2.6 MISCELLANEOUS MATERIALS

**********
**NOTE: The shape, size, thickness of sections, material, and weights for frames, covers, and gratings for inlets and manholes, as well as the amount of waterway opening for inlets and gratings should be indicated on the drawings. The covers and gratings should be designed to have ample strength for the traffic conditions to which they may be subjected. Fixed, straight-type galvanized steel ladders should be provided for manholes over 3.66 m 12 feet deep measured form top of grate to invert of outlet pipe.**
**********

### 2.6.1 Concrete

**********
**NOTE: Reference should be made to other sections of the project specifications, as applicable, or pertinent requirements may be included in this section.**

**The air contents specified are for concrete that will be subjected to freezing weather and the possible action of deicing chemicals. In climates where freezing is not a factor but where air**

**entrainment is used in local commercial practice to improve the workability and placability of concrete, concrete having air content of 4.5 plus or minus 1.5 percent may be specified as Contractor's option to nonairentrained concrete.**

**********

Unless otherwise specified, provide concrete and reinforced concrete conforming to the requirements for [_____] MPa psi concrete under Section 03 30 00 CAST-IN-PLACE CONCRETE. Provide air content by volume of concrete mixture, based on measurements made immediately after discharge from the mixer, of 5 to 7 percent when maximum size of coarse aggregate exceeds 37.5 mm 1-1/2 inches. Determine air content in accordance with ASTM C231/C231M. Provide a minimum concrete covering over steel reinforcing of not less than 25 mm 1 inch thick for covers and not less than 40 mm 1-1/2 inches thick for walls and flooring. For concrete deposited directly against the ground, provide a covering thickness of at least 75 mm 3 inches between steel and ground. Provide expansion-joint filler material conforming to ASTM D1751, or ASTM D1752, or provide be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.6.2 Mortar

Mortar is not allowed for pipe joints. Provide mortar for pipe connections to drainage structures [and brick or block construction] conforming to ASTM C270, Type M, except that the maximum placement time will be 1 hour. Provide a sufficient quantity of water in the mixture to produce a stiff workable mortar but in no case may the quantity exceed [_____] [19] liters [5] gallons of water per sack of cement. Use water that is clean and free of harmful acids, alkalis, and organic impurities. Use the mortar within 30 minutes after the ingredients are mixed with water.

2.6.3 Precast Concrete Segmental Blocks

Provide precast concrete segmental block conforming to ASTM C139, not more than 200 mm 8 inches thick, not less than 200 mm 8 inches long, and of such shape that joints can be sealed effectively and bonded with cement mortar.

2.6.4 Brick

Provide brick conforming to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Provide mortar for jointing and plastering consisting of one part portland cement and two parts fine sand. Lime may be added to the mortar in a quantity not more than 25 percent of the volume of cement. Provide joints that arecompletely filled and that are smooth and free from surplus mortar on the inside of the structure. Plaster brick structures with 13 mm 1/2 inch of mortar over the entire outside surface of the walls. Lay brick in stretcher courses with a header course every sixth course for square or rectangular structures. Lay brick radially with every sixth course a stretcher course for round structures.

2.6.5 Precast Reinforced Concrete Manholes

**********

**NOTE: Rubber-type gasket joints should be specified**

**only where watertightness is essential.**
**********

Provide precast reinforced concrete manholes conforming to ASTM C478/C478M . Provide joints between precast concrete risers and tops that are [full-bedded in cement mortar and smoothed to a uniform surface on both interior and exterior of the structure] [or] [made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph PIPE JOINTS].

2.6.6 Frame and Cover or Gratings

**********
**NOTE: Consider the likelihood of bicycle traffic when selecting the type of inlet grate configuration.**
**********

[Submit certification on the ability of frame and cover or gratings to carry the imposed live load indicated on the drawings.] Provide frame and cover or gratings made of cast gray iron, ASTM A48/A48M, Class 35B; cast ductile iron, ASTM A536, Grade 65-45-12; or cast aluminum, ASTM B26/B26M, Alloy 356.0-T6. [Provide curb inlet grates conforming to the weight, shape, size, and waterway openings indicated on the plans. ]Stamp or cast the word "Storm Sewer" into covers so that it is plainly visible.

2.6.7 Steel Ladder

Provide a steel ladder where the depth of the storm drainage structure exceeds 3.66 m 12 feet. Provide ladders not less than 406 mm 16 inches in width, with 19 mm 3/4 inch diameter rungs spaced 305 mm 12 inches apart. Provide two stringers that are a minimum 10 mm 3/8 inch thick and 63 mm 2-1/2 inches wide. Galvanize ladders and inserts after fabrication in conformance with ASTM A123/A123M.

2.6.8 Resilient Connectors

**********
**NOTE: Delete the requirement for resilient connectors when a watertight connection between pipe and manholes and inlets is not required.**
**********

Provide flexible, watertight connectors conforming to ASTM C923/C923M for connecting pipe to manholes and inlets.

2.6.9 Flared End Sections

2.6.9.1 Metal Flared End Sections

Provide sections of a standard design fabricated from zinc or aluminum (Type 2) coated steel sheets meeting requirements of ASTM A929/A929M.

2.6.9.2 Concrete Flared End Sections

Provide sections of a standard design fabricated with reinforced concrete.

2.6.10 Modular Trench Drains

Provide modular trench drains consisting of [plastic] [or] [precast

concrete] sections. Provide trench with width and invert slope as indicated on the drawings. Provide trench drain sections and grates rated for DIN Class [____].

2.6.10.1 Plastic Sections

Provide polyethylene, polypropylene, polyester, PVC or HDPE sections with UV inhibitors and interlocking tongue and groove joints. Provide channels with [ductile iron] [cast iron] frames.

2.6.10.2 Precast Concrete Sections

Provide concrete sections made of fiber reinforced concrete or polyester polymer concrete with male/female connections between channel sections. Provide channels with [ductile iron] [or] [galvanized steel] [or] [stainless steel] edge rails.

2.6.10.3 Grates

Utilize [ductile iron] [cast iron] [galvanized steel] [stainless steel] trench grates. Attach trench grates to sections as recommended by the manufacturer.

2.6.11 Corrugated Steel Pipe Slotted Drain

**********

**NOTE: Slotted drain fabricated from Type IR corrugated steel pipe is available from some manufacturers.**

**********

Provide slotted drain consisting of galvanized steel grate welded in a continuous slot cut in the top of a corrugated steel pipe. Use Type I corrugated steel pipe conforming to ASTM A760/A760M with zinc coated [____] gage steel sheet and helical 68 by 13 mm 2-2/3 by 1/2 inch corrugations. Provide grates with a 45 mm 1-3/4 inch wide top opening and a [uniform height of [64 mm] [2-1/2 inches] [150 mm] [6 inches] [_____] mm [_____] inches] [variable height as indicated]. Fabricate grating using two [straight] [trapezoidal] sided 4.8 mm 3/16 inch thick steel bearing bars with 4.8 mm 3/16 inch thick steel solid web spacers spaced at 150 mm 6 inch centers. Fabricate grating using steel conforming to ASTM A1011/A1011M, grade 36. Galvanize steel grating in accordance with ASTM A123/A123M. Fillet weld grate to the corrugated steel pipe on each side of the grate at every other corrugation. Join pipe sections with coupling bands.

2.6.12 Downspout Boots

**********

**NOTE: Delete paragraph when downspout boots are not used to connect building downspouts to the storm drainage system.**

**********

Use boots conforming to ASTM A48/A48M, Class 30B or 35B of the size and shape indicated for connecting exterior downspouts to the storm-drainage system.

2.6.13 Flap Gates

Provide [medium] [or] [heavy]-duty flap gates with [circular] [rectangular] openings that are double-hinged. [Provide top pivot points that are adjustable.] Provide one-piece cast iron seats with a raised section around the perimeter of the waterway opening to provide the seating face. Provide [cast iron] [bronze] [stainless steel] [neoprene] seating face. Provide one-piece cast iron covers with necessary reinforcing rib, lifting eye for manual operation, and bosses to provide a pivot point connection with the links. Provide [cast iron] [bronze] [stainless steel] [neoprene] seating face on the cover. Provide cast or ductile iron links and hinge arms. Provide bronze bushings in the holes of pivot points. Provide fasteners that are either galvanized steel, bronze or stainless steel.

2.7 TESTS, INSPECTIONS, AND VERIFICATIONS

2.7.1 Hydrostatic Test on Watertight Joints

**********

**NOTE: The hydrostatic tests specified in this paragraph are performed on a sample joint at the pipe manufacturer's plant or and independent laboratory to demonstrate that the proposed joint will be watertight if properly installed.**

**Retain this paragraph for pipe used in levees and other applications where watertight joints are required.**

**********

Perform a hydrostatic test on the watertight joint types as proposed. This test will be conducted at the plant or by an independent laboratory. Only one sample joint of each type needs testing; however, if the sample joint fails because of faulty design or workmanship, an additional sample joint may be tested.

2.7.1.1 Concrete, Clay, PVC, PE, SRPE and PP Pipe

Provide joints in reinforced and nonreinforced concrete pipe meeting the performance requirements in ASTM C990M ASTM C990 or ASTM C443M ASTM C443. Provide joints in clay pipe meeting the test requirements in ASTM C425. Provide joints in PVC, PE, SRPE, and PP plastic pipe meeting the test requirements in ASTM D3212.

2.7.1.2 Corrugated Steel and Aluminum Pipe

Perform a hydrostatic pressure test on the proposed joining system in accordance with ASTM A760/A760M. The joining system must not leak when subjected to an internal hydrostatic pressure of 69 kPa 10 psi for a 10 minute period

PART 3 EXECUTION

3.1 EXCAVATION FOR PIPE CULVERTS, BOX CULVERTS, STORM DRAINS, AND DRAINAGE STRUCTURES

**********

**NOTE: Reference should be made to other sections of**

**the project specifications, as applicable, or pertinent requirements may be included in this section.**
**********

Excavate trenches, excavate for appurtenances and backfill for culverts and storm drains, in accordance with the applicable portions of Section 31 00 00 EARTHWORK and the requirements specified below.

### 3.1.1 Trenching

**********
**NOTE: The earth load on rigid pipe is dependent on the installation type (trench, positive projecting, and negative projecting). The earth load on a rigid pipe installed in a trench is dependent on the width of the trench. The earth load in a trench can be reduced by minimizing the width of the trench. However, if the trench walls are overexcvated during construction and the trench width is greater than that used for design, the earth load on the pipe may exceed the strength of the pipe. Therefore, it is recommended that all rigid pipe for both embankment and trench conditions be designed for postive projection, embankment conditions.**
**********

Excavate trenches to the width indicated on the drawings or as specified herein. Trench width should permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Place sheeting and bracing, where required, within the trench width as specified, without any overexcavation.

### 3.1.2 Removal of Rock

**********
**NOTE: Unless otherwise specified, material used to replace unstable material or rock excavation should be compacted to a minimum density of 90 percent for cohesive soils and 95 percent for noncohesive soils, as determined by ASTM D1557.**
**********

Replace rock in either ledge or boulder formation with suitable materials to provide a compacted earth cushion. Provide a compacted earth cushion between unremoved rock and the pipe with a thickness of at least 200 mm 8 inches or 13 mm 1/2 inch for each meter foot of fill over the top of the pipe, whichever is greater, but not more than three-fourths the nominal diameter of the pipe. Maintain the cushion under the bell as well as under the straight portion of the pipe where bell-and-spigot pipe is used. Provide a compacted earth cushion between unremoved rock and the box culvert of at least 200 mm 8 inches in thickness for concrete box culverts. Excavate rock as specified and defined in Section 31 00 00 EARTHWORK.

### 3.1.3 Removal of Unstable Material

**********
**NOTE: Coordinate with preceding paragraph.**

**********

Where wet or otherwise unstable soil incapable of properly supporting the pipe or box culvert, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, remove such material to the depth required and replace with select granular material to the proper grade. Compact select granular material as specified in paragraph FINAL BACKFILL. When removal of unstable material is due to the fault or neglect of the Contractor while performing shoring and sheeting, water removal, or other specified requirements, perform such removal and replacement at no additional cost to the Government.

## 3.2 BEDDING AND INITIAL BACKFILL

**********

**NOTE: Pipe cover requirements are different for different types of bedding.**

**********

Provide a firm bedding foundation of uniform density throughout the entire length of the pipe or box culvert.

### 3.2.1 Concrete Pipe

**********

**NOTE: See Section 16 of the AASHTO Bridge Specifications or the American Concrete Pipe Association "Concrete Pipe Design Manual" for pipe installation details.**

**********

Use select granular material conforming to Section 31 00 00 EARTHWORK for haunch and bedding material. Compact haunch and outer bedding to at least [____] [90] percent laboratory maximum density and place in layers not exceeding 150 mm 6 inch loose thickness for compaction by hand-operated compactors and 200 mm 8 inches for other than hand-operated machines. Loosely place middle bedding and do not compact. After the pipe has been properly bedded, place haunch material, at a moisture content that will facilitate compaction, evenly along both sides of the pipe and thoroughly compact each layer with mechanical tampers or rammers to the springline of the pipe. Thoroughly compact the haunch material under the haunches of the pipe. For bell and spigot pipe, form a depression in bedding material for bells so entire barrel of pipe is uniformly supported. Minimize the length, depth, and width of bell depressions to that required for properly making the particular type of joint.

#### 3.2.1.1 Trenches

After the pipe has been properly bedded and haunch material placed to the midpoint (springline) of the pipe, backfill and compact the remainder of the trench by spreading and rolling or compacting by mechanical rammers or tampers in layers not exceeding 150 mm 6 inches. Test for density as necessary to ensure conformance to the compaction requirements specified below. [Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly.] Leave untreated sheeting in place beneath structures or pavements.

3.2.1.2 Fill Sections

For pipe placed in fill sections, uniformly spread fill material longitudinally on both sides of the pipe in layers not exceeding 150 mm 6 inches in compacted depth, and compact by rolling parallel with pipe or by mechanical tamping or ramming. Prior to commencing normal filling operations, the crown width of the fill at a height of 300 mm 12 inches above the top of the pipe must extend a distance of not less than twice the outside pipe diameter on each side of the pipe or 4 m 12 feet, whichever is less. After the backfill has reached at least 300 mm 12 inches above the top of the pipe, place and thoroughly compact the remainder of the fill in layers not exceeding 200 mm 8 inches.

3.2.2 Clay Pipe

Provide bedding for clay pipe as specified by ASTM C12.

3.2.3 Corrugated Steel and Aluminum Pipe

Provide bedding and structural backfill for corrugated steel and aluminum pipe and pipe arch in accordance with ASTM A798/A798M. It is not required to shape the bedding to the pipe geometry. However, for pipe arches, either shape the bedding to the relatively flat bottom arc or fine grade the foundation to a shallow v-shape. Structural backfill material consists of materials classified by ASTM D2487 as either GW, GM, GP-GM, GW-GM, GC, GP-GC or SW. Provide bedding for corrugated structural plate pipe meeting the requirements of ASTM A807/A807M.

3.2.4 Ductile Iron Pipe

Provide bedding for ductile iron pipe as shown on the drawings.

3.2.5 Plastic Pipe

Provide bedding for PVC, PE, SRPE and PP pipe meeting the requirements of ASTM D2321. Use Class IB or II material for PVC, PE, SRPE pipe bedding, haunching, and initial backfill. Use Class I, II, or III material for PP pipe bedding, haunching and initial backfill.

3.2.6 Precast Reinforced Box Culvert

Use granular material a minimum of 150 mm 6 inches in depth for bedding precast concrete box culverts in trenches with soil foundation. Provide granular bedding in trenches with rock foundation that is 13 mm 1/2 inch in depth per 300 mm foot of depth of fill. The minimum depth of bedding will be 200 mm 8 inch up to a maximum depth of 600 mm 24 inches. Loosely place the granular bedding. Provide uniform support along the entire length of box culvert.

3.2.6.1 Trenches

After the box culvert has been properly bedded, place selected material from excavation or borrow, at a moisture content that will facilitate compaction, along both sides of box culvert in layers not exceeding 150 mm 6 inches in compacted depth. Bring the backfill up evenly on both sides of box culvert for the full length box culvert. Thoroughly compact each layer with mechanical tampers or rammers. Continue this method of filling and compacting until the fill has reached an elevation equal to the top of the box culvert. Backfill and compact the remainder of the trench by

spreading and rolling or by compacting with mechanical rammers or tampers in layers not exceeding [_____] mm inches. Test density as necessary to ensure conformance to the compaction requirements specified below. [Where it is necessary, in the opinion of the Contracting Officer, that sheeting or portions of bracing used be left in place, the contract will be adjusted accordingly.] Leave untreated sheeting in place beneath structures or pavements.

3.2.6.2 Fill Sections

Use backfill material and placement and compaction procedures for box culvert placed in fill sections as specified below. Uniformly spread the fill material longitudinally on both sides of the box in layers not exceeding 150 mm 6 inches in compacted depth. Compacted by rolling parallel with pipe or by using mechanical tamping or ramming. Prior to commencing normal filling operations, the width of the fill at a height of 300 mm 12 inches above the top of the box must extend a distance of not less than twice the outside width of the box culvert on each side of the box or 4 m 12 feet, whichever is less. After the backfill has reached at least 300 mm 12 inches above the top of the box, place and thoroughly compacte the remainder of the fill in layers not exceeding [_____] mm inches.

## 3.3 PLACING PIPE AND BOX CULVERT

**********

**NOTE: The Contractor should be required to perform deflection testing when warranted by the scope and size of the project.**

**********

Submit printed copies of the pipe or box culvert manufacturer's recommended pipe or box culvert installation procedures prior to installation. Thoroughly examine each section of pipe or box culvert before being laid; do not use defective or damaged pipe. Protect plastic pipe, excluding SRPE pipe, from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Lay pipelines to the grades and alignment indicated. Provide proper facilities for lowering sections of pipe into trenches. [Place lifting lugs in vertically elongated corrugated steel or aluminum pipe in the same vertical plane as the major axis of the pipe.] Do not lay pipe in water or when trench conditions or weather are unsuitable for such work. Divert drainage or dewater trenches during construction as necessary. Deflection of installed flexible pipe must not exceed the following limits:

| TYPE OF PIPE | MAXIMUM ALLOWABLE DEFLECTION (percent) |
|---|---|
| Corrugated Steel and Aluminum | 5 |
| | |
| Ductile Iron Culvert | 3 |
| Plastic (PVC, HDPE, SRPE, and PP) | 5 |

3.3.1 Concrete, Clay, PVC, Ribbed PVC, Ductile Iron Pipe

Lay pipe proceeding upgrade with spigot ends of bell-and-spigot pipe and tongue ends of tongue-and-groove pipe pointing in the direction of the flow.

3.3.2 Elliptical and Elliptical Reinforced Concrete Pipe

Place pipe so that the manufacturer's reference lines, designating the top of the pipe, are within 5 degrees of a vertical plane through the longitudinal axis of the pipe. Prevent damage to or misalignment of the pipe during backfilling operations.

3.3.3 PE, SRPE, and Dual Wall and Triple Wall PP Pipe

Lay on a bed shaped to line and grade and joint sections together in accordance with manufacturer's guidelines.

3.3.4 Corrugated Steel and Aluminum Pipe and Pipe Arch

**********
**NOTE: Coordinate with paragraph Corrugated Steel Pipe.**
**********

Lay pipe with the separate sections joined firmly together, with the outside laps of circumferential joints pointing upstream, and with longitudinal laps on the sides. Install part paved pipe so that the centerline of bituminous pavement in the pipe, indicated by suitable markings on the top at each end of the pipe sections, coincides with the specified alignment of pipe. Provide fully paved steel pipe or pipe arch with the sheet thickness of the pipe or pipe arch painted or otherwise indicated on a label applied on the inside of the pipe or pipe arch. Coat any unprotected metal in the joints with bituminous material as specified in AASHTO M 190 or AASHTO M 243. Protect interior coating against damage from insertion or removal of struts or tie wires. Use lifting lugs to facilitate moving pipe without damage to exterior or interior coatings. Handle pipe or pipe arch and coupling bands during transportation and installation with care to preclude damage to the coating, paving or lining. Repair damaged coatings, pavings and linings in accordance with the manufacturer's recommendations prior to placing backfill. Remove and replace pipe on with coating, paving or lining that has been damaged to such an extent that satisfactory field repairs cannot be made. Accomplish vertical elongation, where indicated, in the factory. Provide suitable markings or properly placed lifting lugs to ensure placement of factory elongated pipe in a vertical plane.

3.3.5 Structural-Plate Steel

Install structural plate in accordance with ASTM A807/A807M. Assemble structural plate in accordance with instructions furnished by the manufacturer. Instructions must show the position of each plate and the order of assembly. Tighten bolts progressively and uniformly, starting at one end of the structure after all plates are in place. Repeat the operation to ensure that all bolts are tightened to meet the torque requirements of 270 Newton meters 200 foot-pounds plus or minus 68 Newton meters 50 foot-pounds. Check power wrenches used by the use of hand torque wrenches or long-handled socket or structural wrenches for amount of torque produced. Check and adjust power wrenches frequently as needed,

according to type or condition, to ensure proper adjustment to supply the required torque.

### 3.3.6 Structural-Plate Aluminum

Assemble structural plate in accordance with instructions furnished by the manufacturer. Instructions must show the position of each plate and the order of assembly. Tighten bolts progressively and uniformly, starting at one end of the structure after all plates are in place. Repeat the operation to ensure that all bolts are torqued to a minimum of 136 Newton meters 100 foot-pounds on aluminum alloy bolts and a minimum of 203 Newton meters 150 foot-pounds on galvanized steel bolts. Check power wrenches used by the use of hand torque wrenches or long-handled socket or structural wrenches for the amount of torque produced. Check and adjust power wrenches as frequently as needed, according to type or condition, to ensure that they are in proper adjustment to supply the required torque.

### 3.3.7 Multiple Culverts

**********

**NOTE: Where encasement or other special conditions are specified, minimum spacing as specified in this paragraph should not apply.**

**********

Where multiple lines of pipe are installed, adjacent sides of pipe must be at least half the nominal pipe diameter or 1 meter 3 feet apart, whichever is less.

### 3.3.8 Jacking Reinforced Concrete Pipe

Install jacking pipe and operate jacking equipment in accordance with Section 33 05 23 TRENCHLESS UTILITY INSTALLATION.

### 3.3.9 Precast Reinforced Concrete Box Culvert

Proceed upgrade with laying of sections and point tongue ends of tongue-and-groove box culvert section in the direction of flow.

## 3.4 JOINTING

**********

**NOTE: Where watertightness is not required, watertight and at least one other type of joint should be included for each type of pipe required.**

**********

### 3.4.1 Concrete and Clay Pipe

**********

**NOTE: Where watertightness is essential, delete paragraph Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe and Box Culverts below.**

**********

#### 3.4.1.1 Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe and Box Culverts

Follow the recommendation of the particular manufacturer in regard to

sealing compound special installation requirements. When lubricants, primers, or adhesives are used, only apply on surfaces that are dry and clean. Affix sealing compounds to the pipe or box culvert not more than 3 hours prior to installation of the pipe or box culvert. Protect sealing compounds from the sun, blowing dust, and other deleterious agents at all times. Inspect sealing compounds before installation of the pipe or box culvert, and remove and replace any loose or improperly affixed sealing compound. Align the pipe or box culvert with the previously installed pipe or box culvert, and pull the joint together.

3.4.1.2 Flexible Watertight Joints

Use lubricants, cements, adhesives, and other special installation requirements for gaskets and jointing materials as recommended by the manufacturer. When lubricants, cements, or adhesives are used, only apply on surfaces that are clean and dry. Affix gaskets and jointing materials to the pipe not more than 24 hours prior to the installation of the pipe, and protect from the sun, blowing dust, and other deleterious agents at all times. Inspect gaskets and jointing materials before installing the pipe; remove and replace any loose or improperly affixed gaskets and jointing materials. Align the pipe with the previously installed pipe, and push the joint home. If the gasket becomes visibly dislocated when joining sections of pipe, remove the pipe and remake the joint.

3.4.2 Corrugated Steel and Aluminum Pipe

3.4.2.1 Field Joints

**********

**NOTE: Delete this paragraph where watertightness is essential.**

**In the text below, delete bracketed sentence, regarding filling of annular space, except when pipe 750 mm 30 inches in diameter and larger is included in the project. Delete reference to pipe size except when necessary to differentiate from corrugated metal pipe of less than 750 mm (30 inch) diameter which is also included in the project.**

**********

Provide transverse field joints designed so that the successive connection of pipe sections will form a continuous line free of appreciable irregularities in the flow line. Provide joints meeting the general performance requirements described in ASTM A798/A798M. Suitable transverse field joints which satisfy the requirements for one or more of the joint performance categories can be obtained with the following types of connecting bands furnished with suitable band-end fastening devices: corrugated bands, bands with projections, flat bands, and bands of special design that engage factory reformed ends of corrugated pipe. Keep the space between the pipe and connecting bands free from dirt and grit so that corrugations fit snugly. While being tightened, tap the connecting band with a soft-head mallet of wood, rubber or plastic, to take up slack and ensure a tight joint. [Fill the annular space between abutting sections of part paved, and fully paved pipe and pipe arch, in sizes 750 mm 30 inches or larger, with a bituminous material after jointing.] Provide field joints for each type of corrugated metal pipe that maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installations. [Provide bands of the type, size,

and sheet thickness indicated. Provide angles or lugs and bolts of the size indicated.] [Provide bands and angles or lugs and bolts as specified in the applicable standards or specifications for the pipe.]

3.4.2.2 Flexible Watertight, Gasketed Joints

Use lubricants or cements and other special installation requirements as recommended by the gasket manufacturer. Where sleeve type gaskets are used, place the gasket over one end of a section of pipe for half the width of the gasket. Then double over the other half over the end of the same pipe. When the adjoining section of pipe is in place, roll the doubled-over half of the gasket over the adjoining section. Correct any unevenness in overlap so that the gasket covers the end of pipe sections equally. Center connecting bands over adjoining sections of pipe, and place rods or bolts in position and tighten nuts. Band Tightening: Tighten the band evenly, keep even tension on the rods or bolts, and the gasket; properly seat the gasket in the corrugations. Keep watertight joints uncovered for a period of time designated by the Contracting Officer. Before covering joints, measure the tightness of the nuts with a torque wrench. If the nut has tended to loosen its grip on the bolts or rods, retighten the nut with a torque wrench and keep uncovered until a tight, permanent joint is assured.

3.5 DRAINAGE STRUCTURES

**********

**NOTE: Coordinate with paragraph MISCELLANEOUS MATERIALS.**

**********

3.5.1 Manholes and Inlets

**********

**NOTE: Prepare the required paragraph or section covering the essential requirements for reinforced concrete inlet construction and insert the required reference to the paragraph or section prepared to cover these items.**

**Delete the requirement for flexible watertight connectors (last sentence) when a watertight connection between pipe and manholes and inlets is not required.**

**Construct new manholes and inlets of reinforced concrete. Brick or precast concrete segmental block should typically not be used to construct new manholes.**

**********

Construct manholes of precast reinforced concrete. Construct inlets of [precast] [or] [cast in place] reinforced concrete. Provide manholes and inlets complete with frames and covers or gratings[; and with fixed galvanized steel ladders] as indicated. [The wall along the line where steel ladders are installed must be vertical for its entire length. Adequately anchor ladders to the wall by means of steel inserts spaced not more than 1.83 m 6 feet vertically, and install to provide at least 150 mm 6 inches of space between the wall and the rungs.] [Make pipe connections to concrete manholes and inlets with flexible, watertight connectors.]

3.5.2 Walls and Headwalls

**********

**NOTE: Dry-stone masonry may be specified and used for crib construction and/or sloping retaining walls that will sustain little or no earth pressure.**

**********

Construct [walls] [headwalls] as indicated.

3.6 INSTALLATION OF TRACER WIRE AND WARNING TAPE

**********

**NOTE: Delete paragraph when tracer wire or warning tape is not installed above storm drain pipe.**

**********

[Install a continous length of tracer wire for the full length of each run of nonmetallic pipe in accordance with Section 31 00 00 EARTHWORK. Attach wire to top of pipe in such a manner that it will not be displaced during construction operations.] [Install warning tape above all storm drain pipe in accordance with Section 31 00 00 EARTHWORK.]

3.7 UNDERGROUND STORMWATER RETENTION/DETENTION SYSTEM

Install [pipe] [and] [collection chambers] as recommended by the manufacturer. Place foundation and embedment stone as recommended by the manufacturer of the [pipe] [collection chambers]. Begin compaction of initial fill after 300 mm 12 inches of material have been placed over the [pipe] [chambers]. Compact initial fill in 150 mm 6 inch thick layers to 90 percent maximum density. Use roller with a gross vehicle weight not exceeding 53 kN 12,000 lbs and a dynamic force not exceeding 89 kN 20,000 lbs.

3.8 FINAL BACKFILL

**********

**NOTE: The thickness of layers of backfill and the degree of compaction required to prevent undesirable settlement should be determined by soil conditions and the job compaction requirements.**

**********

Backfill trenches with satisfactory material deposited in layers of a maximum of 200 mm 8 inches loose thickness and compacted to 90 percent of maximum density for cohesive soils and 95 percent of maximum density for cohesionless soils in accordance with Section 31 00 00 EARTHWORK. Testing is the responsibility of the Contractor and will be performed at no additional cost to the Government. Unless otherwise specified, determine field in-place density of final backfill at a frequency of one test per 15 linear meters 50 linear feet, or fraction thereof, of each lift of backfill. Submit test results in accordance with Section 31 00 00 EARTHWORK. Do not displace or damage pipe or box when compacting final backfill by rolling or operating heavy equipment parallel with the pipe or box. Movement of construction machinery over a culvert or storm drain at any stage of construction will be at the Contractor's risk. Repair or replace any damaged pipe. Protect concrete pipes with a minimum of 1 meter

3 feet of cover prior to permitting heavy construction equipment to pass over them during construction. Provide the minimum cover for construction loads over corrugated steel pipes as specified in Section 26, Division II of AASHTO HB-17. Provide minimum cover for construction loads over plastic pipes as specified in ASTM D2321.

## 3.9 FIELD QUALITY CONTROL

### 3.9.1 Tests

Testing is the responsibility of the Contractor. Perform all testing and retesting at no additional cost to the Government.

#### [3.9.1.1 Leakage Test

**********

**NOTE: Leakage tests can be performed to verify that watertight joints were installed correctly during placement of the pipe. Most projects will not warrant the use of a leakage test.**

**Field-test joints in pipe installed through levees for watertightness in accordance with EM 1110-2-2902.**

**Delete paragraph when watertight joints are not required. Also, delete the paragraph when watertight joints are required, but the quantity of pipe required for a project (except levees) is so small that the provisions for testing and certification of watertightness of joints is economically unfeasible. Field testing of joints in pipe through levees for watertightness is required regardless of the size of the project.**

**********

Test pipe lines for leakage prior to completing backfill by performing either an exfiltration test, low pressure air pipeline test or by individual pipe joint testing. Submit leakage test results to the Contracting Officer.

##### 3.9.1.1.1 Exfiltration Test

**********

**NOTE: Exfiltration tests can be difficult to perform, expecially with larger diameter pipes.**

**Select appropriate leakage rate.**

**********

Prior to exfiltration tests, backfill the trench up to at least the lower half of the pipe. If required, place sufficient additional backfill to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. When the water table is 600 mm 2 feet or more above the top of the pipe at the upper end of the pipeline section to be tested, measure infiltration using a suitable weir or other device acceptable to the Contracting Officer. Perform exfiltration test by filling the line to be tested with water so that a head of at least 600 mm 2 feet is provided above both the water table and the top of the pipe at the upper end of the

pipeline to be tested. Allow the filled line to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, reestablish the head. Measure the amount of water required to maintain this water level during a 2-hour test period. Leakage as measured by the exfiltration test must not exceed [23 liters per mm in diameter per kilometer250 gallons per inch in diameter per mile of pipeline per day] [98 mL per mm in diameter per 100 meters0.2 gallons per inch in diameter per 100 feet of pipeline per hour]. Correct visible leaks encountered regardless of leakage test results.

3.9.1.1.2 Low Pressure Air Pipeline Tests

**********
**NOTE: The integrity of joints in installed pipes can be determined by pressuring isolated segments of pipe with air and measuring pressure loss.**
**********

Perform low pressure air testing for vitrified clay pipes in accordance with ASTM C828. Perform low pressure air testing for plastic pipe in accordance with ASTM F1417. Perform low pressure air testing procedures for other pipe materials using the pressures and testing times prescribed in ASTM C828, after consultation with the pipe manufacturer.

3.9.1.1.3 Individual Pipe Joint Testing

**********
**NOTE: The integrity of joints in large (675 mm 27-inch and larger diameter) installed pipes can be determined by testing each joint for leakage using air or water.**
**********

Testing of individual joints for leakage by low pressure air or water must conform to ASTM C1103M ASTM C1103.

][3.9.1.2 Deflection Testing

**********
**NOTE: Specify laser profiler or mandrel inspection of flexible pipes only when warranted by scope or size of project or when watertightness is required.**

**Do not use laser profiler inspections for Navy projects.**

**Delete this paragraph when no flexible piping has been allowed for the project.**
**********

Conduct deflection test no sooner than 30 days after completion of final backfill and compaction testing. Clean or flush all lines prior to testing. Perform a deflection test on entire length of installed flexible pipeline upon completion of work adjacent to and over the pipeline, including backfilling, placement of fill, grading, paving, placement of concrete, and any other superimposed loads. Deflection of pipe in the installed pipeline under external loads must not exceed the limits in paragraph PLACING PIPE AND BOX CULVERT above as percent of the average inside diameter of pipe. Use a [laser profiler or] mandrel to determine

if allowable deflection has been exceeded.

[3.9.1.2.1 Laser Profiler

**********
**NOTE: Delete last sentence in brackets if pipes larger than 1200 mm 48 inches are not included in the project.**
**********

Inspect pipe interior with laser profiling equipment. Utilize low barrel distortion video equipment in accordance with UFGS 33 01 30.16 TV INSPECTION OF SEWER LINES for pipe diameters 1200 mm 48 inches or less. [For initial post installation inspections for pipe diameters larger than 1200 mm 48 inches, perform a visual inspection of the pipe interior.]

][3.9.1.2.2 Mandrel

Pass the mandrel through each run of pipe by pulling it by hand. If deflection readings in excess of the allowable deflection of average inside diameter of pipe are obtained, stop and begin test from the opposite direction. The mandrel must meet the pipe manufacturer's recommendations and the following requirements. Provide a mandrel that is rigid, nonadjustable, has a minimum of 9 fins, pulling rings at each end, and is engraved with the nominal pipe size and mandrel outside diameter. The mandrel must be 5 percent less that the ceritified-actual pipe diameter for plastic pipe, 5 percent less than the certified-actual pipe diameter for corrugated steel and aluminum, 3 percent less than the certified-actual pipe diameter for ductile iron culvert pipe. The Government will verify the outside diameter (OD) of the Contractor provided mandrell through the use of Contractor provided proving rings.

]]3.9.1.3 Tracer Wire Continuity

**********
**NOTE: Delete this paragraph when tracer wire is not being installed above storm drain pipe.**
**********

Test tracer wire for continuity after initial and final backfilling of pipes. Verify that tracer wire is locatable with electronic utility location equipement. Repair breaks or separations and re-test for continuity.

3.9.2 Inspection

[3.9.2.1 Post-Installation Inspection

**********
**NOTE: Delete the requirement for a post-installation CCTV inspection of pipes when the quantity of pipe required for a project is so small that it is economically unfeasible.**
**********

[Perform a CCTV inspection and video recording of pipes with diameters 1200 mm 48 inches or less in accordance with UFGS 33 01 30.16 TV INSPECTION OF SEWER LINES. Visually inspect pipes with diameters larger than 1200 mm 48 inches.] Inspect each segment of pipe for alignment,

settlement, joint separations, soil migration through the joint, cracks, buckling, bulging and deflection. An engineer must evaluate all defects to determine if any remediation or repair is required.

[3.9.2.1.1 Concrete Pipe

An engineer must evaluate all pipes with cracks with a width greater than 0.25 mm 0.01 inches, but less than 2.5 mm 0.10 inches to determine if any remediation or repair is required.

][3.9.2.1.2 Flexible Pipe

Check each flexible pipe (PE, PVC, PP, corrugated steel and aluminum) for rips, tears, joint separations, soil migration throught the joint, cracks, localized buckling, bulges, settlement and alignment.

][3.9.2.1.3 Post-Installation Inspection Report

The deflection results and final post installation inspection report must include: [a copy of all video taken,] pipe location identification, equipment used for inspection, inspector name, deviation from design, grade, deviation from line, deflection and deformation of flexible pipe, inspector notes, condition of joints, condition of pipe wall (e.g. distress, cracking, wall damage dents, bulges, creases, tears, holes, etc.).

]]3.9.2.2 Low Impact Development Inspection

**********

**NOTE: For Navy, include a Low Impact Development (LID) inspection to comply with UFC 3-210-10 and FC 1-300-09N Navy and Marine Corps Design Procedures.**

**Navy policy requires LID data to be reported annually. The LID Verification Report must be downloaded from the Whole Building Design Guide (WBDG) and attached to this specification section. The Designer of Record (DoR) is responsible for completing the design portion of the report prior to attaching it to this specification.**

**Government approval was added to ensure that the submittal is delivered to the Government and not the Contractor's DoR for Design Build projects.**

**The LID Verification Report referenced in this section is only listed as an attachment on the Section Table of Contents during Process Print/Publish. The LID Verification Report must be manually inserted to the printed Job or added to the PDF using Adobe Acrobat features.**

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Inspect Low Impact Development (LID) features indicated on the design portion of the LID Verification Report. Certify LID features were constructed according to plans and specifications or by submitting as-built drawings in accordance with UFGS 01 78 00 Closeout Submittals. When as-built drawings show deviations to the LID features, document the deviations on the LID Verification Report.

3.9.3 Repair of Defects

3.9.3.1 Leakage Test

When leakage exceeds the maximum amount specified, correct source of excess leakage by replacing damaged pipe and gaskets and retest.

3.9.3.2 Deflection Testing

When deflection readings are in excess of the allowable deflection of average inside diamater of pipe are obtained, remove pipe which has excessive deflection and replace with new pipe. Retest 30 days after completing backfill, leakage testing and compaction testing.

3.9.3.3 Inspection

Replace pipe or repair defects indicated in the Post-Installation Inspection Report.

3.9.3.3.1 Concrete Pipe

Replace pipes having cracks with a width greater than 2.5 mm 0.1 inches.

3.9.3.3.2 Flexible Pipe

Replace pipes having cracks or splits.

3.10 PROTECTION

Protect storm drainage piping and adjacent areas from superimposed and external loads during construction.

3.11 WARRANTY PERIOD

Pipe segments found to have defects during the warranty period must be replaced with new pipe and retested.

-- End of Section --