**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

**References are in agreement with UMRL dated January 2021**
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DIVISION 33 - UTILITIES

SECTION 33 40 00

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**02/10, CHG 6: 02/19**

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|---|---|
| **USACE / NAVFAC / AFCEC / NASA** | **UFGS-33 40 00 (February 2010)**<br>**Change 6 - 02/19** |
| | **----------** |
| **Preparing Activity: USACE** | **Superseding**<br>**UFGS-33 40 00 (August 2009)** |

**UNIFIED FACILITIES GUIDE SPECIFICATIONS**

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SECTION 33 40 00

STORM DRAINAGE UTILITIES
**02/10, CHG 6: 02/19**

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**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).**

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PART 1 GENERAL

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**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 available.**

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

**8. Store 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

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**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.**

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### 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 Storm Drainage Structures

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**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.

1.1.3 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.

1.1.4 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.

1.1.5 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.

1.1.6 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; this cost shall be included in the Contractor's 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.

### 1.1.7 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.

### 1.1.8 Pipe Placed by Jacking

Payment will be made for the number of linear meters feet of jacked pipe accepted in the completed work measured along the centerline of the pipe in place.

## 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.**

**********

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 167M/M 167 | (2017) Standard Specification for Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches |
| AASHTO M 190 | (2004; R 2017) Standard Specification for Asphalt-Coated Corrugated Metal Culvert Pipe and Pipe Arches |

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| AASHTO M 219 | (1992; R 2017) Standard Specification for Corrugated Aluminum Alloy Structural Plate for Field-Bolted Pipe, Pipe-Arches, and Arches |
| AASHTO M 243 | (1996; R 2017) Standard Specification for Field-Applied Coating of Corrugated Metal Structural Plate for Pipe, Pipe-Arches, and Arches |
| AASHTO M 294 | (2017) Standard Specification for Corrugated Polyethylene Pipe, 300- to 1500-mm (12- to 60-in.) Diameter |
| AASHTO MP 20 | (2013; R 2017) Standard Specification for Steel-Reinforced Polyethylene (PE) Ribbed Pipe, 300- to 1500-mm (12- to 60-in) Diameter |

AMERICAN CONCRETE INSTITUTE (ACI)

| | |
|---|---|
| ACI 346 | (2009) Specification for Cast-in-Place Concrete Pipe |

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

| | |
|---|---|
| AREMA Eng Man | (2017) Manual for Railway Engineering |

ASTM INTERNATIONAL (ASTM)

| | |
|---|---|
| ASTM A48/A48M | (2003; R 2016) 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) Standard Specification for Ductile Iron Culvert Pipe |
| ASTM A742/A742M | (2020) Standard Specification for Steel Sheet, Metallic Coated and Polymer Precoated for Corrugated Steel Pipe |
| ASTM A760/A760M | (2015, R 2020) Standard Specification for Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains |
| ASTM A762/A762M | (2019) Standard Specification for Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains |
| ASTM A798/A798M | (2017) Standard Practice for Installing Factory-Made Corrugated Steel Pipe for Sewers and Other Applications |

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| ASTM A807/A807M | (2017) Standard Practice for Installing Corrugated Steel Structural Plate Pipe for Sewers and Other Applications |
| ASTM A849 | (2015) Standard Specification for Post-Applied Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe |
| ASTM A929/A929M | (2018) Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe |
| ASTM B26/B26M | (2014; E 2015) Standard Specification for Aluminum-Alloy Sand Castings |
| ASTM B745/B745M | (2015) Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains |
| ASTM C12 | (2017) Standard Practice for Installing Vitrified Clay Pipe Lines |
| ASTM C14 | (2020) Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe |
| ASTM C14M | (2020) Standard Specification for 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 | (2017) Standard Specification for Concrete Building Brick |
| ASTM C62 | (2017) Standard Specification for Building Brick (Solid Masonry Units Made from Clay or Shale) |
| ASTM C76 | (2020) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe |
| ASTM C76M | (2020) Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe (Metric) |
| ASTM C139 | (2017) Standard Specification for Concrete Masonry Units for Construction of Catch Basins and Manholes |
| ASTM C231/C231M | (2017a) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method |
| ASTM C270 | (2019) Standard Specification for Mortar |

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| | for Unit Masonry |
| ASTM C425 | (2004; R 2013) Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings |
| ASTM C443 | (2020) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets |
| ASTM C443M | (2020) Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets (Metric) |
| ASTM C444 | (2017) Standard Specification for Perforated Concrete Pipe |
| ASTM C444M | (2017) Standard Specification for Perforated Concrete Pipe (Metric) |
| ASTM C478 | (2018) Standard Specification for Circular Precast Reinforced Concrete Manhole Sections |
| ASTM C478M | (2018) Standard Specification for Precast Reinforced Concrete Manhole Sections (Metric) |
| ASTM C506 | (2020) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe |
| ASTM C506M | (2020) Standard Specification for Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe (Metric) |
| ASTM C507 | (2020) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe |
| ASTM C507M | (2020) Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe (Metric) |
| ASTM C655 | (2014) Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe |
| ASTM C700 | (2013) Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated |
| ASTM C828 | (2011) Low-Pressure Air Test of Vitrified Clay Pipe Lines |
| ASTM C877 | (2008) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections |
| ASTM C877M | (2002; R 2009) External Sealing Bands for Concrete Pipe, Manholes, and Precast Box |

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|---|---|
| | Sections (Metric) |
| ASTM C923 | (2008; R 2013; E 2016) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals |
| ASTM C923M | (2008b; R 2013) Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes and Laterals (Metric) |
| ASTM C969 | (2019) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines |
| ASTM C969M | (2019) Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines (Metric) |
| ASTM C990 | (2009; R 2014) Standard Specification for Joints for Concrete Pipe, Manholes and Precast Box Sections Using Preformed Flexible Joint Sealants |
| ASTM C1103 | (2019) 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 | (2018) Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers (Metric) |
| ASTM D1056 | (2014) Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber |
| ASTM D1171 | (2016; E 2016) Standard Test Method for Rubber Deterioration - Surface Ozone Cracking Outdoors (Triangular Specimens) |
| ASTM D1557 | (2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3) |
| ASTM D1751 | (2004; E 2013; R 2013) Standard Specification for Preformed Expansion |

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| | 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 D1784 | (2020) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds |
| ASTM D2167 | (2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method |
| ASTM D2321 | (2020) Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications |
| ASTM D2729 | (2017) Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings |
| ASTM D3034 | (2016) Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings |
| ASTM D3212 | (2007; R 2020) Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals |
| ASTM D3350 | (2012) Polyethylene Plastics Pipe and Fittings Materials |
| ASTM D6938 | (2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth) |
| ASTM F477 | (2014) Standard Specification for 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 | (2013; R 2019) Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter |
| ASTM F794 | (2003; R 2014) Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter |
| ASTM F894 | (2019) Standard Specification for |

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|---|---|
| | 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 F2562/F2562M | (2015) Specification for Steel Reinforced Thermoplastic Ribbed Pipe and Fittings for Non-Pressure Drainage and Sewerage |
| ASTM F2736 | (2013; E 2014) Standard Specification for 6 to 30 in. (152 To 762 mm) Polypropylene (PP) Corrugated Single Wall Pipe And Double Wall Pipe |
| ASTM F2764/F2764M | (2018a) 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 | (2011) Standard Specification for 12 to 60 in. (300 to 1500 mm) Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications |

## 1.3 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-04 Samples

Pipe for Culverts and Storm Drains

SD-07 Certificates

Resin Certification

Oil Resistant Gasket

Leakage Test

Hydrostatic Test on Watertight Joints

Determination of Density

Frame and Cover for Gratings

Post-Installation Inspection Report

SD-08 Manufacturer's Instructions

Placing Pipe

SD-11 Closeout Submittals

Lid Verification Report; G

## 1.4 DELIVERY, STORAGE, AND HANDLING

### 1.4.1 Delivery and Storage

Materials delivered to site shall be inspected for damage, unloaded, and stored with a minimum of handling. Materials shall not be stored directly on the ground. The inside of pipes and fittings shall be kept free of dirt and debris. Before, during, and after installation, plastic pipe and fittings shall be protected 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. Solvents, solvent compounds, lubricants, elastomeric gaskets, and any similar materials required to install plastic pipe shall be stored in accordance with the manufacturer's recommendations and shall be discarded if the storage period exceeds the recommended shelf life. Solvents in use shall be discarded when the recommended pot life is exceeded.

1.4.2 Handling

Materials shall be handled in a manner that ensures delivery to the trench in sound, undamaged condition. Pipe shall be carried to the trench, not dragged.

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 for the various sizes should be specified.**

**The pipe class, the type of joint, and installation procedures should be as specified in Section 33 30 00 SANITARY SEWERAGE and Section 33 31 23.00 10 SANITARY SEWER FORCE MAIN PIPING.**

**Pipe materials which are known to be unsuitable for local conditions (i.e., corrosion, root penetration, etc.) should not be permitted for the project. However, consideration should be given to the use of protective coatings and jointing methods 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 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.**

**********

Pipe for culverts and storm drains shall be of the sizes indicated and shall conform to the requirements specified.

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.**

**********

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

2.1.1.1 Reinforced Arch Culvert and Storm Drainpipe

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

2.1.1.2 Reinforced Elliptical Culvert and Storm Drainpipe

Manufactured in accordance with and conforming to ASTM C507M ASTM C507. Horizontal elliptical pipe shall be Class [HE-A] [HE-I] [HE-II] [HE-III] [HE-IV]. Vertical elliptical pipe shall be Class [VE-II] [VE-III] [VE-IV] [VE-V] [VE-VI].

2.1.1.3 Nonreinforced Pipe

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

2.1.1.4 Cast-In-Place Nonreinforced Conduit

**********

**NOTE: This type conduit should not be used beneath structures, for drain crossings, adjacent to paved areas, or under high fills.**

**********

ACI 346, except that testing shall be the responsibility of and at the expense of the Contractor. In the case of other conflicts between ACI 346 and project specifications, requirements of ACI 346 shall govern.

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.**

**********

Standard or extra strength, as indicated, conforming to ASTM C700.

2.1.3 Corrugated Steel Pipe

**********

**NOTE: The several different metallic coatings may not provide equal protection of the base metal against corrosion and /or abrasion in all environments. For severe environments, a combination of special coatings may be required to provide the desired service life. Additional protection for corrugated steel pipe may be provided by use of non-metallic coatings applied before or after fabrication of the pipe. A description of available coatings and durability guidelines is included in the National Corrugated Steel Pipe Association (NCSPA) publication "Modern Sewer Design".**

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

**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.**

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

**specified.**

**For Army, corrugated steel pipe is also available in a form called "nestable culvert pipe." This pipe is furnished in semi-cylindrical pieces which are fastened together on the job site to form a pipeline of round cross section. Nestable culvert pipe was developed as a means of conserving shipping and storage space, and its use should be considered when such space is at a premium, as in some overseas projects, etc. When specified, nestable culvert pipe should conform to MIL-P-236. Other newly-developed products may be included subject to approval, on a case-by-case basis, by HQUSACE (CEMP-ET) Washington, DC 20314-1000.**

**For Navy, indicate sheet thickness on the drawings.**

**********

ASTM A760/A760M, zinc or aluminum (Type 2) coated pipe of either:

a. Type [I] [II] pipe with [annular] [helical] 68 by 13 mm 2-2/3 by 1/2 inch corrugations.

b. Type [IR] [IIR] pipe with helical 19 by 19 by 190 mm 3/4 by 3/4 by 7-1/2 inch corrugations.

2.1.3.1 Fully Bituminous Coated

AASHTO M 190 Type A and ASTM A760/A760M zinc or aluminum (Type 2) coated pipe of either:

a. Type [I] [II] pipe with [annular] [helical] 68 by 13 mm 2-2/3 by 1/2 inch corrugations.

b. Type [IR] [IIR] pipe with helical 19 by 19 by 190 mm 3/4 by 3/4 by 7-1/2 inch corrugations.

2.1.3.2 Half Bituminous Coated, Part Paved

AASHTO M 190 Type B and ASTM A760/A760M zinc or aluminum (Type 2) coated Type [I] [II] pipe with [annular] [helical] 68 by 13 mm 2-2/3 by 1/2 inch corrugations.

2.1.3.3 Fully Bituminous Coated, Part Paved

AASHTO M 190 Type C and ASTM A760/A760M zinc or aluminum (Type 2) coated Type [I] [II] pipe with [annular] [helical] 68 by 13 mm 2-2/3 by 1/2 inch corrugations.

2.1.3.4 Fully Bituminous Coated, Fully Paved

AASHTO M 190 Type D and ASTM A760/A760M zinc or aluminum (Type 2) coated Type [I] [II] pipe with [annular] [helical] 68 by 13 mm 2-2/3 by 1/2 inch corrugations.

2.1.3.5 Concrete-Lined

**********

**NOTE: Concrete-lined corrugated steel pipe combines the structural economy of corrugated steel pipe with the hydraulic efficiency of a concrete lining to provide an alternative to reinforced concrete pipe.**

**Smooth-lined corrugated pipe and pipe arch will not be given hydraulic credit for the lining unless it can be demonstrated that the lining will last for the full service life of the project. If the lining will last for the full service life, use the same "n" value as for concrete pipe. If the lining will not last the full service life, use the "n" value for uncoated corrugated pipe or pipe arch.**

**********

ASTM A760/A760M zinc coated Type I corrugated steel pipe with [annular] [helical] 68 by 13 mm 2-2/3 by 1/2 inch corrugations and a concrete lining in accordance with ASTM A849.

2.1.3.6 Polymer Precoated

ASTM A762/A762M corrugated steel pipe fabricated from ASTM A742/A742M Grade 250/250 10/10 polymer precoated sheet of either:

a. Type [I] [II] pipe with [annular] [helical] 68 by 13 mm 2-2/3 by 1/2 inch corrugations.

b. Type [IR] [IIR] pipe with helical 19 by 19 by 190 mm 3/4 by 3/4 by 7-1/2 inch corrugations.

2.1.3.7 Polymer Precoated, Part Paved

ASTM A762/A762M Type [I] [II] corrugated steel pipe and AASHTO M 190 Type B (modified), paved invert only, fabricated from ASTM A742/A742M Grade 250/250 10/10 polymer precoated sheet with [annular] [helical] 68 by 13 mm 2-2/3 by 1/2 inch corrugations.

2.1.3.8 Polymer Precoated, Fully Paved

ASTM A762/A762M Type [I] [II] corrugated steel pipe and AASHTO M 190 Type D (modified), fully paved only, fabricated from ASTM A742/A742M Grade 250/250 10/10 polymer precoated sheet with [annular] [helical] 68 by 13 mm 2-2/3 by 1/2 inch corrugations.

2.1.4 Corrugated Aluminum Pipe

**********

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

**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.**

**For Navy, do not use AASHTO M 190 Type C, concrete lining on aluminum materials.**

**********

ASTM B745/B745M corrugated aluminum pipe of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IA] [IR] [IIA] [IIR] pipe with helical corrugations.

2.1.4.1 Aluminum Fully Bituminous Coated

Bituminous coating shall conform to ASTM A849 Type [_____]. Piping shall conform to AASHTO M 190 Type A and ASTM B745/B745M corrugated aluminum pipe of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IA] [IR] [IIA] [IIR] pipe with helical corrugations.

2.1.4.2 Aluminum Fully Bituminous Coated, Part Paved

Bituminous coating shall conform to ASTM A849 Type [_____]. Piping shall conform to AASHTO M 190 Type C and ASTM B745/B745M corrugated aluminum alloy pipe of either:

a. Type [I] [II] pipe with [annular] [helical] corrugations.

b. Type [IR] [IIR] pipe with helical corrugations.

2.1.5 Structural Plate, Steel Pipe, Pipe Arches and Arches

**********

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

**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.**

**********

Assembled with galvanized steel nuts and bolts, from galvanized corrugated steel plates conforming to AASHTO M 167M/M 167. Pipe coating, when required, shall conform to the requirements of [AASHTO M 190 Type A] [ AASHTO M 243]. Thickness of plates shall be as indicated.

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.**
**********

Assembled with either aluminum alloy, aluminum coated steel, stainless steel or zinc coated steel nuts and bolts. Nuts and bolts, and aluminum alloy plates shall conform to AASHTO M 219. Pipe coating, when required, shall conform to the requirements of [AASHTO M 190, Type A] [AASHTO M 243 ]. Thickness of plates shall be as indicated.

2.1.7 Ductile Iron Culvert Pipe

ASTM A716.

2.1.8 Poly Vinyl Chloride (PVC) Pipe

Submit the pipe manufacturer's resin certification, indicating the cell classification of PVC used to manufacture the pipe, prior to installation of the pipe.

2.1.8.1 Type PSM PVC Pipe

ASTM D3034, Type PSM, maximum SDR 35, produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.8.2 Profile PVC Pipe

ASTM F794, Series 46, produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.8.3 Smooth Wall PVC Pipe

ASTM F679 produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.8.4 Corrugated PVC Pipe

ASTM F949 produced from PVC certified by the Manufacturer as meeting the requirements of ASTM D1784, minimum cell class 12454-B.

2.1.9 Polyethylene (PE) Pipe

Submit the pipe manufacturer's resin certification, indicating the cell classification of PE used to manufacture the pipe, prior to installation of the pipe. The minimum cell classification for polyethylene plastic shall apply to each of the seven primary properties of the cell classification limits in accordance with ASTM D3350.

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. Pipe shall be produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 335434C.

2.1.9.2 Corrugated PE Pipe

**********

**NOTE: Corrugated PE pipe culverts and storm drains shall not be installed beneath airfield pavements unless approved in writing by the major command. Type S pipe has a full circular cross-section, with an outer corrugated pipe wall and a smooth inner liner. Type C pipe has a full circular cross-section, with a corrugated surface both inside and outside. Corrugations may be either annular or helical.**

**********

AASHTO M 294, Type [S] [C]. For slow crack growth resistance, acceptance of resins shall be determined by using the notched constant ligament-stress (NCLS) test meeting the requirements of AASHTO M 294. Pipe walls shall have 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, produced from PE certified by the resin producer as meeting the requirements of ASTM D3350, minimum cell class 334433C. Pipe walls shall have 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) | |
|---|---|---|---|
| | | 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

SRPE pipe will meet the requirements of ASTM F2562/F2562M 200 - 3000 mm 8 - 120 inch diameter pipe and AASHTO MP 20 (300 - 1525 (12 - 60 inch diameter pipe).

2.1.11 Polypropylene (PP) Pipe

Double wall and triple wall pipe with a diameter of 300 to 1525 mm 12 to 60 inches shall meet the requirements of ASTM F2736, ASTM F2764/F2764M, or ASTM F2881.

2.2 PERFORATED PIPING

**********
**NOTE: For Navy, do not use pipe sizes greater than 10 inches 250 mm in diameter.**
**********

2.2.1 Clay Pipe

ASTM C700, [standard] [extra] strength.

2.2.2 Concrete Pipe

Manufactured in accordance with and conforming to ASTM C444M ASTM C444, and applicable requirements of ASTM C14M ASTM C14, Class [_____].

2.2.3 Corrugated Steel Pipe

ASTM A760/A760M, Type III, zinc-coated.

2.2.4 Corrugated Aluminum Pipe

ASTM B745/B745M, Type III.

2.2.5 Polyvinyl Chloride (PVC) Pipe

ASTM D2729.

2.2.6 Polypropylene (PP) Pipe

ASTM F2881, Class II perforation patterns.

2.3 DRAINAGE STRUCTURES

2.3.1 Flared End Sections

Sections shall be of a standard design fabricated from zinc coated steel sheets meeting requirements of ASTM A929/A929M.

2.3.2 Precast Reinforced Concrete Box

**********

**NOTE: Where sulfate-resistant pipe is required and concrete pipe is to be an option, the use of Type II or Type V cement will be specified.**

**********

Manufactured in accordance with and conforming to ASTM C1433M ASTM C1433.

2.4 MISCELLANEOUS MATERIALS

**********

**NOTE: The shape, size, thickness of sections, kinds of materials, 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.**

**********

2.4.1 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, concrete and reinforced concrete shall conform to the requirements for [_____] MPa psi concrete under Section 03 30 00 CAST-IN-PLACE CONCRETE. The concrete mixture shall have air content by volume of concrete, 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. Air content shall be determined in accordance with ASTM C231/C231M. The concrete covering over steel reinforcing shall not be less than 25 mm 1 inch thick for covers and not less than 40 mm 1-1/2 inches thick for walls and flooring. Concrete covering deposited directly against the ground shall have a thickness of at least 75 mm 3 inches between steel and ground. Expansion-joint filler material shall conform to ASTM D1751, or ASTM D1752, or shall be resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752.

2.4.2 Mortar

Mortar for pipe joints, connections to other drainage structures, and brick or block construction shall conform to ASTM C270, Type M, except that the maximum placement time shall be 1 hour. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar but in no case shall exceed [_____] liters gallons of water per sack of cement. Water shall be clean and free of harmful acids, alkalis, and organic impurities. The mortar shall be used within 30 minutes after the ingredients are mixed with water. The inside of the joint shall be wiped clean and finished smooth. The mortar head on the outside shall be protected from air and sun with a proper covering until satisfactorily cured.

2.4.3 Precast Concrete Segmental Blocks

Precast concrete segmental block shall conform 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.

2.4.4 Brick

Brick shall conform to ASTM C62, Grade SW; ASTM C55, Grade S-I or S-II; or ASTM C32, Grade MS. Mortar for jointing and plastering shall consist 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. The joints shall be filled completely and shall be smooth and free from surplus mortar on the inside of the structure. Brick structures shall be plastered with 13 mm 1/2 inch of mortar over the entire outside surface of the walls. For square or rectangular structures, brick shall be laid in stretcher courses with a header course every sixth course. For round structures, brick shall be laid radially with every sixth course a stretcher course.

2.4.5 Precast Reinforced Concrete Manholes

**********

**NOTE: Rubber-type gasket joints should be specified only where watertightness is essential.**

**********

Conform to ASTM C478M ASTM C478. Joints between precast concrete risers and tops shall be [full-bedded in cement mortar and shall be smoothed to a uniform surface on both interior and exterior of the structure] [made with flexible watertight, rubber-type gaskets meeting the requirements of paragraph JOINTS].

2.4.6 Prefabricated Corrugated Metal Manholes

**********
**NOTE: For Navy, do not use corrgated metal manholes.**
**********

Manholes shall be of the type and design recommended by the manufacturer. Manholes shall be complete with frames and cover, or frames and gratings.

2.4.7 Frame and Cover for Gratings

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

Submit certification on the ability of frame and cover or gratings to carry the imposed live load. Frame and cover for gratings shall be 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.O-T6. Weight, shape, size, and waterway openings for grates and curb inlets shall be as indicated on the plans. The word "Storm Sewer" shall be stamped or cast into covers so that it is plainly visible.

2.4.8 Joints

2.4.8.1 Flexible Watertight Joints

**********
**NOTE: This paragraph covers compression-type rubber-gasketed joints. When pipe requiring a pressure-type joint is specified, the requirements of this paragraph may not apply and the joint should be made in accordance with the specifications for the pipe.**
**********

a. Flexible watertight joints shall be made with plastic or rubber-type gaskets for concrete pipe and with factory-fabricated resilient materials for clay pipe. The design of joints and the physical requirements for preformed flexible joint sealants shall conform to ASTM C990, and rubber-type gaskets shall conform to ASTM C443M ASTM C443. Factory-fabricated resilient joint materials shall conform to ASTM C425. Gaskets shall have not more than one factory-fabricated splice, except that two factory-fabricated splices of the rubber-type gasket are permitted if the nominal diameter of the pipe being gasketed exceeds 1.35 m 54 inches.

b. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443M ASTM C443. Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing

materials are installed. Alternate types of watertight joint may be furnished, if specifically approved.

2.4.8.2 External Sealing Bands

Requirements for external sealing bands shall conform to ASTM C877M ASTM C877.

2.4.8.3 Flexible Watertight, Gasketed Joints

**********
**NOTE: The inapplicable type of gasket material should be deleted. Type 2A1 should be specified where specific resistance to the action of petroleum base oils is not required. Type 2B3 has specific requirements for oil resistance with low swell. Fill in blank for any other combination of Class and Grade required.**
**********

a. Gaskets: When infiltration or exfiltration is a concern for pipe lines, the couplings may be required to have gaskets. The closed-cell expanded rubber gaskets shall be a continuous band approximately 178 mm 7 inches wide and approximately 10 mm 3/8 inch thick, meeting the requirements of ASTM D1056, Type 2 [A1] [B3] [_____], and shall 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. Rubber O-ring gaskets shall be 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. Rubber O-ring gaskets shall be 35 mm 1-3/8 inches in diameter for pipe having 25 mm 1 inch deep end corrugations. O-rings shall meet the requirements of ASTM C990 or ASTM C443M ASTM C443. Preformed flexible joint sealants shall conform to ASTM C990, Type B.

b. Connecting Bands: Connecting bands shall be of the type, size and sheet thickness of band, and the size of angles, bolts, rods and lugs as indicated or where not indicated as specified in the applicable standards or specifications for the pipe. Exterior rivet heads in the longitudinal seam under the connecting band shall be countersunk or the rivets shall be omitted and the seam welded. Watertight joints shall be tested and shall meet the test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS.

2.4.8.4 PVC Plastic Pipes

Joints shall be solvent cement or elastomeric gasket type in accordance with the specification for the pipe and as recommended by the pipe manufacturer.

2.4.8.5 Smooth Wall PE Plastic Pipe

Pipe shall be joined using butt fusion method as recommended by the pipe manufacturer.

2.4.8.6 Corrugated PE Plastic Pipe

Pipe joints shall be [soil] [silt] [water] tight and shall conform to the requirements in AASHTO M 294.[ Water tight joints shall be made using a

PE coupling and rubber gaskets as recommended by the pipe manufacturer. Rubber gaskets shall conform to ASTM F477.]

2.4.8.7 Profile Wall PE Plastic Pipe

Joints shall be gasketed or thermal weld type with integral bell in accordance with ASTM F894.

2.4.8.8 Ductile Iron Pipe

Couplings and fittings shall be as recommended by the pipe manufacturer.

2.4.8.9 Dual Wall and Triple Wall PP Pipe

Spigot shall have two gaskets meeting the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and 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 for 300 to 1500 mm 12 to 60 inches pipe][ASTM F2736 for 300 to 750 mm 12 to 30 inches pipe][ASTM F2764/F2764M for 750 to 1500 mm 30 to 60 inches pipe] diameters shall have a reinforced bell with a polymer composite band installed by the manufacturer. Fittings shall conform to [ASTM F2881] [ASTM F2736] [ASTM F2764/F2764M]. Bell and spigot connections shall utilize a spun-on, welded or integral bell and spigot with gaskets meeting ASTM F477.

2.4.8.10 Steel Reinforced Polyethylene (SRPE) Pipe

SRPE joints shall meet the requirements of ASTM D3212.

2.4.9 Flap Gates

Flap Gates shall be [medium] [or] [heavy]-duty with [circular] [rectangular] opening and double-hinged. [Top pivot points shall be adjustable.] The seat shall be one-piece cast iron with a raised section around the perimeter of the waterway opening to provide the seating face. The seating face of the seat shall be [cast iron] [bronze] [stainless steel] [neoprene]. The cover shall be one-piece cast iron with necessary reinforcing rib, lifting eye for manual operation, and bosses to provide a pivot point connection with the links. The seating face of the cover shall be [cast iron] [bronze] [stainless steel] [neoprene]. Links or hinge arms shall be cast or ductile iron. Holes of pivot points shall be bronze bushed. All fasteners shall be either galvanized steel, bronze or stainless steel.

2.5 STEEL LADDER

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

2.6 RESILIENT CONNECTORS

**********

**NOTE: Delete the requirement for resilient connectors when a watertight connection between pipe**

**and manholes and inlets is not required.**
**********

Flexible, watertight connectors used for connecting pipe to manholes and inlets shall conform to ASTM C923M ASTM C923.

## 2.7 EROSION CONTROL RIP RAP

Provide non-erodible rock not exceeding 375 mm 15 inches in its greatest dimension and choked with sufficient small rocks to provide a dense mass with a minimum thickness of [200 mm] [8 inches] [as indicated].

# PART 3 EXECUTION

## 3.1 INSTALLATION OF PIPE 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.**
**********

Excavation of trenches, and for appurtenances and backfilling for culverts and storm drains, shall be in accordance with the applicable portions of Section 31 00 00 EARTHWORK, 31 23 00.00 20 EXCAVATION AND FILL and the requirements specified below.

### 3.1.1 Trenching

**********
**NOTE: Economic considerations should determine the width of trench to be used in the design analysis and to be specified for construction. Where it is more economical to control trench width and thereby use less costly pipe, the width of the trench shall vary with the pipe diameter and should be held to a minimum consistent with the space required for proper installation of the pipe and the backfill at the sides of the pipe. Where the sides of the excavations are to be supported, proper allowance should be made for the space occupied by the sheeting and bracing.**
**********

The width of trenches at any point below the top of the pipe shall be not greater than the outside diameter of the pipe plus [_____] mm inches to permit satisfactory jointing and thorough tamping of the bedding material under and around the pipe. Sheeting and bracing, where required, shall be placed within the trench width as specified, without any overexcavation. Where trench widths are exceeded, redesign with a resultant increase in cost of stronger pipe or special installation procedures will be necessary. Cost of this redesign and increased cost of pipe or installation shall be borne by the Contractor without additional cost to the Government.

### 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.**

Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between unremoved rock and the pipe 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. Where bell-and-spigot pipe is used, the cushion shall be maintained under the bell as well as under the straight portion of the pipe. Rock excavation shall be as specified and defined in Section 31 00 00 EARTHWORK 31 23 00.00 20 EXCAVATION AND FILL .

### 3.1.3 Removal of Unstable Material

**NOTE: Coordinate with preceding paragraph.**

Where wet or otherwise unstable soil incapable of properly supporting the pipe, as determined by the Contracting Officer, is unexpectedly encountered in the bottom of a trench, such material shall be removed to the depth required and replaced to the proper grade with select granular material, compacted as provided in paragraph BACKFILLING. 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, such removal and replacement shall be performed at no additional cost to the Government.

## 3.2 BEDDING

**NOTE: It should be noted that pipe cover requirements will be different for different types of bedding.**

The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe.

### 3.2.1 Concrete Pipe Requirements

When no bedding class is specified or detailed on the drawings, concrete pipe shall be bedded in granular material minimum 100 mm 4 inch in depth in trenches with soil foundation. Depth of granular bedding in trenches with rock foundation shall be 13 mm 1/2 inch in depth per 300 mm foot of depth of fill, minimum depth of bedding shall be 200 mm 8 inch up to maximum depth of 600 mm 24 inches. The middle third of the granular bedding shall be loosely placed. Bell holes and depressions for joints shall be removed and formed so entire barrel of pipe is uniformly supported. The bell hole and depressions for the joints shall be not more than the length, depth, and width required for properly making the particular type of joint.

### 3.2.2 Clay Pipe Requirements

Bedding for clay pipe shall be as specified by ASTM C12.

### 3.2.3 Corrugated Steel and Aluminum Pipe

Bedding for corrugated steel and aluminum pipe and pipe arch shall be 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. Bedding for corrugated structural plate pipe shall meet requirements of ASTM A807/A807M.

### 3.2.4 Ductile Iron Pipe

Bedding for ductile iron pipe shall be as shown on the drawings.

### 3.2.5 Plastic Pipe

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

## 3.3 PLACING PIPE

**********

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

**********

Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Plastic pipe, excluding SRPE pipe shall be protected from exposure to direct sunlight prior to laying, if necessary to maintain adequate pipe stiffness and meet installation deflection requirements. Pipelines shall be laid to the grades and alignment indicated. Proper facilities shall be provided for lowering sections of pipe into trenches. Lifting lugs in vertically elongated pipe shall be placed in the same vertical plane as the major axis of the pipe. Pipe shall not be laid in water, and pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches during construction shall be provided as necessary. Deflection of installed flexible pipe shall not exceed the following limits:

| TYPE OF PIPE | MAXIMUM ALLOWABLE DEFLECTION (percent) |
|---|---|
| Corrugated Steel and Aluminum | 5 |
| Concrete-Lined Corrugated Steel | 3 |
| | |
| Plastic (PVC, PE, SRPE, and PP) | 5 |

Note post installation requirements of paragraph DEFLECTION TESTING in PART 3 of this specification for all pipe products including deflection

testing requirements for flexible pipe.

### 3.3.1 Concrete, Clay, PVC, Ribbed PVC, Ductile Iron and Cast-Iron Pipe

Laying shall proceed 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

The manufacturer's reference lines, designating the top of the pipe, shall be within 5 degrees of a vertical plane through the longitudinal axis of the pipe, during placement. Damage to or misalignment of the pipe shall be prevented in all backfilling operations.

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

Laying shall be with the separate sections joined firmly on a bed shaped to line and grade and shall follow manufacturer's guidelines.

### 3.3.4 Corrugated Steel and Aluminum Pipe and Pipe Arch

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

Laying shall be with the separate sections joined firmly together, with the outside laps of circumferential joints pointing upstream, and with longitudinal laps on the sides. Part paved pipe shall be installed 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. Fully paved steel pipe or pipe arch shall have a painted or otherwise applied label inside the pipe or pipe arch indicating sheet thickness of pipe or pipe arch. Any unprotected metal in the joints shall be coated with bituminous material as specified in AASHTO M 190 or AASHTO M 243. Interior coating shall be protected against damage from insertion or removal of struts or tie wires. Lifting lugs shall be used to facilitate moving pipe without damage to exterior or interior coatings. During transportation and installation, pipe or pipe arch and coupling bands shall be handled with care to preclude damage to the coating, paving or lining. Damaged coatings, pavings and linings shall be repaired in accordance with the manufacturer's recommendations prior to placing backfill. Pipe on which coating, paving or lining has been damaged to such an extent that satisfactory field repairs cannot be made shall be removed and replaced. Vertical elongation, where indicated, shall be accomplished by factory elongation. Suitable markings or properly placed lifting lugs shall be provided to ensure placement of factory elongated pipe in a vertical plane.

### 3.3.5 Structural-Plate Steel

Structural plate shall be installed in accordance with ASTM A807/A807M. Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated 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. Any power wrenches used shall be checked by the use of hand torque wrenches or long-handled socket or structural wrenches for amount of torque produced. Power wrenches shall be checked and adjusted frequently as needed, according to type or condition, to ensure proper adjustment to supply the required torque.

### 3.3.6 Structural-Plate Aluminum

Structural plate shall be assembled in accordance with instructions furnished by the manufacturer. Instructions shall show the position of each plate and the order of assembly. Bolts shall be tightened progressively and uniformly, starting at one end of the structure after all plates are in place. The operation shall be repeated 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. Any power wrenches used shall be checked by the use of hand torque wrenches or long-handled socket or structural wrenches for the amount of torque produced. Power wrenches shall be checked and adjusted 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 shall be at least half the nominal pipe diameter or 1 meter 3 feet apart, whichever is less.

### 3.3.8 Jacking Pipe Through Fills

Methods of operation and installation for jacking pipe through fills shall conform to requirements specified in Volume 1, Chapter 1, Part 4 of AREMA Eng Man.

## 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. Where watertightness is essential, delete paragraphs Cement-Mortar Bell-and-Spigot Joint through Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe below.**

**********

### 3.4.1 Concrete and Clay Pipe

#### 3.4.1.1 Cement-Mortar Bell-and-Spigot Joint

The first pipe shall be bedded to the established grade line, with the bell end placed upstream. The interior surface of the bell shall be thoroughly cleaned with a wet brush and the lower portion of the bell

filled with mortar as required to bring inner surfaces of abutting pipes flush and even. The spigot end of each subsequent pipe shall be cleaned with a wet brush and uniformly matched into a bell so that sections are closely fitted. After each section is laid, the remainder of the joint shall be filled with mortar, and a bead shall be formed around the outside of the joint with sufficient additional mortar. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint shall be wrapped or bandaged with cheesecloth to hold mortar in place.

#### 3.4.1.2 Cement-Mortar Oakum Joint for Bell-and-Spigot Pipe

A closely twisted gasket shall be made of jute or oakum of the diameter required to support the spigot end of the pipe at the proper grade and to make the joint concentric. Joint packing shall be in one piece of sufficient length to pass around the pipe and lap at top. This gasket shall be thoroughly saturated with neat cement grout. The bell of the pipe shall be thoroughly cleaned with a wet brush, and the gasket shall be laid in the bell for the lower third of the circumference and covered with mortar. The spigot of the pipe shall be thoroughly cleaned with a wet brush, inserted in the bell, and carefully driven home. A small amount of mortar shall be inserted in the annular space for the upper two-thirds of the circumference. The gasket shall be lapped at the top of the pipe and driven home in the annular space with a caulking tool. The remainder of the annular space shall be filled completely with mortar and beveled at an angle of approximately 45 degrees with the outside of the bell. If mortar is not sufficiently stiff to prevent appreciable slump before setting, the outside of the joint thus made shall be wrapped with cheesecloth. Placing of this type of joint shall be kept at least five joints behind laying operations.

#### 3.4.1.3 Cement-Mortar Diaper Joint for Bell-and-Spigot Pipe

The pipe shall be centered so that the annular space is uniform. The annular space shall be caulked with jute or oakum. Before caulking, the inside of the bell and the outside of the spigot shall be cleaned.

a. Diaper Bands: Diaper bands shall consist of heavy cloth fabric to hold grout in place at joints and shall be cut in lengths that extend one-eighth of the circumference of pipe above the spring line on one side of the pipe and up to the spring line on the other side of the pipe. Longitudinal edges of fabric bands shall be rolled and stitched around two pieces of wire. Width of fabric bands shall be such that after fabric has been securely stitched around both edges on wires, the wires will be uniformly spaced not less than 200 mm 8 inches apart. Wires shall be cut into lengths to pass around pipe with sufficient extra length for the ends to be twisted at top of pipe to hold the band securely in place; bands shall be accurately centered around lower portion of joint.

b. Grout: Grout shall be poured between band and pipe from the high side of band only, until grout rises to the top of band at the spring line of pipe, or as nearly so as possible, on the opposite side of pipe, to ensure a thorough sealing of joint around the portion of pipe covered by the band. Silt, slush, water, or polluted mortar grout forced up on the lower side shall be forced out by pouring, and removed.

c. Remainder of Joint: The remaining unfilled upper portion of the joint shall be filled with mortar and a bead formed around the outside of

this upper portion of the joint with a sufficient amount of additional mortar. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind actual laying of pipe. No backfilling around joints shall be done until joints have been fully inspected and approved.

#### 3.4.1.4 Cement-Mortar Tongue-and-Groove Joint

The first pipe shall be bedded carefully to the established grade line with the groove upstream. A shallow excavation shall be made underneath the pipe at the joint and filled with mortar to provide a bed for the pipe. The grooved end of the first pipe shall be thoroughly cleaned with a wet brush, and a layer of soft mortar applied to the lower half of the groove. The tongue of the second pipe shall be cleaned with a wet brush; while in horizontal position, a layer of soft mortar shall be applied to the upper half of the tongue. The tongue end of the second pipe shall be inserted in the grooved end of the first pipe until mortar is squeezed out on interior and exterior surfaces. Sufficient mortar shall be used to fill the joint completely and to form a bead on the outside.

#### 3.4.1.5 Cement-Mortar Diaper Joint for Tongue-and-Groove Pipe

The joint shall be of the type described for cement-mortar tongue-and-groove joint in this paragraph, except that the shallow excavation directly beneath the joint shall not be filled with mortar until after a gauze or cheesecloth band dipped in cement mortar has been wrapped around the outside of the joint. The cement-mortar bead at the joint shall be at least 13 mm 1/2 inch, thick and the width of the diaper band shall be at least 200 mm 8 inches. The diaper shall be left in place. Placing of this type of joint shall be kept at least five joints behind the actual laying of the pipe. Backfilling around the joints shall not be done until the joints have been fully inspected and approved.

#### 3.4.1.6 Plastic Sealing Compound Joints for Tongue-and-Grooved Pipe

Sealing compounds shall follow the recommendation of the particular manufacturer in regard to special installation requirements. Surfaces to receive lubricants, primers, or adhesives shall be dry and clean. Sealing compounds shall be affixed to the pipe not more than 3 hours prior to installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Sealing compounds shall be inspected before installation of the pipe, and any loose or improperly affixed sealing compound shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pulled together. If, while making the joint with mastic-type sealant, a slight protrusion of the material is not visible along the entire inner and outer circumference of the joint when the joint is pulled up, the pipe shall be removed and the joint remade. After the joint is made, all inner protrusions shall be cut off flush with the inner surface of the pipe. If non-mastic-type sealant material is used, the "Squeeze-Out" requirement above will be waived.

#### 3.4.1.7 Flexible Watertight Joints

Gaskets and jointing materials shall be as recommended by the particular manufacturer in regard to use of lubricants, cements, adhesives, and other special installation requirements. Surfaces to receive lubricants, cements, or adhesives shall be clean and dry. Gaskets and jointing materials shall be affixed to the pipe not more than 24 hours prior to the

installation of the pipe, and shall be protected from the sun, blowing dust, and other deleterious agents at all times. Gaskets and jointing materials shall be inspected before installing the pipe; any loose or improperly affixed gaskets and jointing materials shall be removed and replaced. The pipe shall be aligned with the previously installed pipe, and the joint pushed home. If, while the joint is being made the gasket becomes visibly dislocated the pipe shall be removed and the joint remade.

3.4.1.8 External Sealing Band Joint for Noncircular Pipe

Surfaces to receive sealing bands shall be dry and clean. Bands shall be installed in accordance with manufacturer's recommendations.

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 inches diameter which is also included in the project.**
**********

Transverse field joints shall be designed so that the successive connection of pipe sections will form a continuous line free of appreciable irregularities in the flow line. In addition, the joints shall meet 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. The space between the pipe and connecting bands shall be kept free from dirt and grit so that corrugations fit snugly. The connecting band, while being tightened, shall be tapped with a soft-head mallet of wood, rubber or plastic, to take up slack and ensure a tight joint. [The annular space between abutting sections of part paved, and fully paved pipe and pipe arch, in sizes 750 mm 30 inches or larger, shall be filled with a bituminous material after jointing.] Field joints for each type of corrugated metal pipe shall maintain pipe alignment during construction and prevent infiltration of fill material during the life of the installations. The type, size, and sheet thickness of the band and the size of angles or lugs and bolts shall be as indicated or where not indicated, shall be as specified in the applicable standards or specifications for the pipe.

3.4.2.2 Flexible Watertight, Gasketed Joints

Installation shall be as recommended by the gasket manufacturer for use of lubricants and cements and other special installation requirements. The gasket shall be placed over one end of a section of pipe for half the width of the gasket. The other half shall be doubled over the end of the

same pipe. When the adjoining section of pipe is in place, the doubled-over half of the gasket shall then be rolled over the adjoining section. Any unevenness in overlap shall be corrected so that the gasket covers the end of pipe sections equally. Connecting bands shall be centered over adjoining sections of pipe, and rods or bolts placed in position and nuts tightened. Band Tightening: The band shall be tightened evenly, even tension being kept on the rods or bolts, and the gasket; the gasket shall seat properly in the corrugations. Watertight joints shall remain uncovered for a period of time designated, and before being covered, tightness of the nuts shall be measured with a torque wrench. If the nut has tended to loosen its grip on the bolts or rods, the nut shall be retightened with a torque wrench and remain 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.**

**********

Construction shall be of reinforced concrete, plain concrete, brick, precast reinforced concrete, precast concrete segmental blocks, prefabricated corrugated metal, or bituminous coated corrugated metal; complete with frames and covers or gratings; and with fixed galvanized steel ladders where indicated. Pipe studs and junction chambers of prefabricated corrugated metal manholes shall be fully bituminous-coated and paved when the connecting branch lines are so treated. Pipe connections to concrete manholes and inlets shall be made 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.**

**********

Construction shall be as indicated.

## 3.6 STEEL LADDER INSTALLATION

Ladder shall be adequately anchored to the wall by means of steel inserts

spaced not more than 1.83 m 6 feet vertically, and shall be installed to provide at least 152 mm 6 inches of space between the wall and the rungs. The wall along the line of the ladder shall be vertical for its entire length.

## 3.7 BACKFILLING

**********

**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. When rigid pipe is to be placed under high fills, the imperfect trench method of installation may be specified.**

**********

### 3.7.1 Backfilling Pipe in Trenches

After the pipe has been properly bedded, selected material from excavation or borrow, at a moisture content that will facilitate compaction, shall be placed along both sides of pipe in layers not exceeding 150 mm 6 inches in compacted depth. The backfill shall be brought up evenly on both sides of pipe for the full length of pipe. The fill shall be thoroughly compacted under the haunches of the pipe. Each layer shall be thoroughly compacted with mechanical tampers or rammers. This method of filling and compacting shall continue until the fill has reached an elevation equal to the midpoint (spring line) of concrete pipe or has reached an elevation of at least 300 mm 12 inches above the top of the pipe for flexible pipe. The remainder of the trench shall be backfilled and compacted by spreading and rolling or compacted by mechanical rammers or tampers in layers not exceeding [_____] mm inches. Tests for density shall be made 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. Untreated sheeting shall not be left in place beneath structures or pavements.

### 3.7.2 Backfilling Pipe in Fill Sections

For pipe placed in fill sections, backfill material and the placement and compaction procedures shall be as specified below. The fill material shall be uniformly spread in layers longitudinally on both sides of the pipe, not exceeding 150 mm 6 inches in compacted depth, and shall be compacted 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 shall 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, the remainder of the fill shall be placed and thoroughly compacted in layers not exceeding [_____] mm inches. Use select granular material for this entire region of backfill for flexible pipe installations.

### 3.7.3 Movement of Construction Machinery

When compacting by rolling or operating heavy equipment parallel with the pipe, displacement of or injury to the pipe shall be avoided. Movement of construction machinery over a culvert or storm drain at any stage of construction shall be at the Contractor's risk. Any damaged pipe shall be

repaired or replaced.

3.7.4 Compaction

3.7.4.1 General Requirements

Cohesionless materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Cohesive materials include clayey and silty gravels, gravel-silt mixtures, clayey and silty sands, sand-clay mixtures, clays, silts, and very fine sands. When results of compaction tests for moisture-density relations are recorded on graphs, cohesionless soils will show straight lines or reverse-shaped moisture-density curves, and cohesive soils will show normal moisture-density curves.

3.7.4.2 Minimum Density

**********
**NOTE: For culverts or storm drains installed beneath structures (including embankments) that have critical stability requirements or settlement limitations, the maximum density requirements should be increased as necessary. If only a cohesive soil or only a cohesionless material will be used as backfill, the inapplicable value will be deleted.**
**********

Backfill over and around the pipe and backfill around and adjacent to drainage structures shall be compacted at the approved moisture content to the following applicable minimum density, which will be determined as specified below.

a. Under airfield and heliport pavements, paved roads, streets, parking areas, and similar-use pavements including adjacent shoulder areas, the density shall be not less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.

b. Under unpaved or turfed traffic areas, density shall not be less than 90 percent of maximum density for cohesive material and 95 percent of maximum density for cohesionless material.

c. Under nontraffic areas, density shall be not less than that of the surrounding material.

3.8 FIELD PAINTING

3.8.1 Cast-Iron Covers, Frames, Gratings, And Steps

After installation, clean cast-iron, not buried in masonry or concrete, of mortar, rust, grease, dirt, and other deleterious materials to bare metal and apply a coat of bituminous paint.

3.8.2 Steel Covers And Frames Or Concrete Frames

After installation, clean steel or concrete, not buried in masonry or concrete, of mortar, dirt, grease, and other deleterious materials to bare metal. Apply a coat of primer, [ ], to a minimum dry film thickness of [ ] mm mil; and apply a top coat, [ ] to a minimum dry film

thickness of [ ] mm mils, color optional. Painting must conform to Section 09 90 00 PAINTS AND COATINGS. Do not paint surfaces subject to abrasion.

## 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.

**********

**NOTE: Delete paragraph when watertight joints are not required.**

**When the quantity of pipe required for a project is so small that the provisions for testing and certification of watertightness of joints appears to be economically unfeasible, such provisions should be deleted.**

**********

#### [3.9.1.1 HYDROSTATIC TEST ON WATERTIGHT JOINTS

Watertight joints shall be tested and shall meet test requirements of paragraph HYDROSTATIC TEST ON WATERTIGHT JOINTS. Rubber gaskets shall comply with the oil resistant gasket requirements of ASTM C443M ASTM C443. Certified copies of test results shall be delivered to the Contracting Officer before gaskets or jointing materials are installed.

##### 3.9.1.1.1 Concrete, Clay, PVC, PE, SRPE and PP Pipe

A hydrostatic test shall be made on the watertight joint types as proposed. 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. During the test period, gaskets or other jointing material shall be protected from extreme temperatures which might adversely affect the performance of such materials. Performance requirements for joints in reinforced and nonreinforced concrete pipe shall conform to ASTM C990 or ASTM C443M ASTM C443. Test requirements for joints in clay pipe shall conform to ASTM C425. Test requirements for joints in PVC, PE, and PP plastic pipe shall conform to ASTM D3212.

##### 3.9.1.1.2 Corrugated Steel and Aluminum Pipe

**********

**NOTE: The pipe length tested for hydrostatic test on joints must not exceed the "Allowable span in feet for CSP Flowing Full," TABLE 4.5, of American Iron and Steel Institute Publication "Handbook of Steel Drainage and Highway Construction Products". The joint is in the center of the sample tested, the supports should be at 21 percent of the sample length from the ends of the sample to develop 15 percent moment when filled with water.**

**********

A hydrostatic test shall be made on the watertight joint system or

coupling band type proposed. The moment strength required of the joint is expressed as 15 percent of the calculated moment capacity of the pipe on a transverse section remote from the joint by the AASHTO HB-17 (Division II, Section 26). The pipe shall be supported for the hydrostatic test with the joint located at the point which develops 15 percent of the moment capacity of the pipe based on the allowable span in meters feet for the pipe flowing full or 54,233 Newton meters 40,000 foot-pounds, whichever is less. Performance requirements shall be met at an internal hydrostatic pressure of 69 kPa 10 psi, for a 10 minute period for both annular corrugated steel and aluminum pipe and helical corrugated steel and aluminum pipe with factory reformed ends.

][3.9.1.2 Leakage Test

**********
**NOTE: Delete this paragraph when hydrostatic test is used.**

**Select appropriate leakage rate.**
**********

Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests, as appropriate, prior to completing backfill. Low pressure air testing for vitrified clay pipes shall conform to ASTM C828. Low pressure air testing for concrete pipes shall conform to ASTM C969M ASTM C969. Low pressure air testing for plastic pipe shall conform to ASTM F1417. Low pressure air testing procedures for other pipe materials shall use the pressures and testing times prescribed in ASTM C828 or ASTM C969M ASTM C969, after consultation with the pipe manufacturer. Testing of individual joints for leakage by low pressure air or water shall conform to ASTM C1103M ASTM C1103. Prior to exfiltration tests, the trench shall be backfilled up to at least the lower half of the pipe. If required, sufficient additional backfill shall be placed to prevent pipe movement during testing, leaving the joints uncovered to permit inspection. Visible leaks encountered shall be corrected regardless of leakage test results. 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, infiltration shall be measured using a suitable weir or other device acceptable to the Contracting Officer. An exfiltration test shall be made 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. The filled line shall be allowed to stand until the pipe has reached its maximum absorption, but not less than 4 hours. After absorption, the head shall be reestablished. The amount of water required to maintain this water level during a 2-hour test period shall be measured. Leakage as measured by the exfiltration test shall not exceed [60 liters per mm in diameter per kilometer 250 gallons per inch in diameter per mile of pipeline per day] [ 9 mL per mm in diameter per 100 meters 0.2 gallons per inch in diameter per 100 feet of pipeline per hour].

]3.9.1.3 Determination of Density

Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. Tests shall be performed in sufficient number to ensure that specified density is being obtained. Laboratory tests for moisture-density relations shall be made in accordance with ASTM D1557 except that mechanical tampers may be used provided the results are correlated with those obtained with the specified

hand tamper. Field density tests shall be determined in accordance with ASTM D2167 or ASTM D6938. When ASTM D6938 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in paragraph Calibration of the referenced publications. ASTM D6938 results in a wet unit weight of soil and ASTM D6938 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D6938. Test results shall be furnished the Contracting Officer. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed.

[3.9.1.4 Deflection Testing

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

**For Navy, delete laser profiler inspection.**

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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 shall not exceed limits in paragraph PLACING PIPE above as percent of the average inside diameter of pipe. Use a [laser profiler or] mandrel to determine if allowable deflection has been exceeded.

[3.9.1.4.1 Laser Profiler

Inspect pipe interior with laser profiling equipment. Utilize low barrel distortion video equipment for pipe sizes 1.22 m 48 inches or less. Use a camera with suitable lighting to allow a clear picture of the entire periphery of the pipe interior. Center the camera in the pipe both vertically and horizontally. The camera must be able to pan and tilt to a 90 degree angle with the axis of the pipe rotating 360 degrees. Use equipment to move the camera through the pipe that will not obstruct the camera's view or interfere with proper documentation of the pipe's condition. The video image shall be clear, focused, and relatively free from roll static or other image distortion qualities that would prevent the reviewer from evaluating the condition of the pipe. For initial post installation inspections for pipe sizes larger than 1.22 m 48 inches, a visual inspection shall be completed of the pipe interior.

][3.9.1.4.2 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 Manufacture'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 than the certified-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 Concrete-Lined Corrugated Steel and Ductile Iron Culvert. The Government will verify the outside diameter(OD)of the Contractor provided mandrel through the use of Contractor provided proving rings.

]]3.9.2 Inspection

3.9.2.1 Post-Installation Inspection

Visually inspect each segment of concrete 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

Cracks with a width greater than 0.25 mm 0.01 inches. 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, Corregated Steel And Aluminum) for rips, tears, joint separations, soil migration through the joint, cracks, localized bucking, 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

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**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. 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 diameter 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

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 --