

Section 33 42 11

STORMWATER GRAVITY PIPING

[This spec addresses water-tight RCP and Polypropylene pipe 12"-60"]

ITEMS HIGHLIGHTED REQUIRE THE ENGINEER TO REVIEW CROSS REFERENCE SPECIFICATIONS AND/OR MAKE A SELECTION BASED ON REQUIRED PERFORMANCE

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Section 33 42 11 – STORM DRAINAGE UTILITIES

PART 1 — GENERAL

1.1 Related Requirements

A. Section 01 33 00 – Submittals: Shop Drawings, Product Data, and Samples

B. Section 31 23 00 – Earth Moving: Excavation and Fill

1.2 Summary

- A. This section includes gravity-flow storm drainage outside the building, with the following components:
 - 1. Drainage piping, fittings, and accessories

1.3 Reference Standards

- 1.3.1 American Association of State Highway and Transportation Officials (AASHTO)
 - A. AASHTO LRFD Bridge Construction Specifications: Section 27 – Concrete Culverts
 - B. AASHTO LRFD Bridge Construction Specifications: Section 30 – Thermoplastic Pipe
 - C. AASHTO M170 Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe
 - D. AASHTO M 242 Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe
 - E. AASHTO M315 Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
 - F. AASHTO M330 Polypropylene Pipe 300- 1500-mm (12- to 60-in.) Diameter
 - G. AASHTO R16 Regulatory Information Used in AASHTO Tests
 - H. AASHTO R 82-17 Standard Practice for Pipe Joint Selection for Highway Culvert and Storm Drains
 - I. AASHTO T99 Standard Method of Test for Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop
 - J. AASHTO T341 Determination of Compression Capacity for profile Wall pipe by Stub Compression Loading

1.3.2 American Society for Testing and Materials (ASTM)

- A. ASTM A615 – Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
- B. ASTM C76 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
- C. ASTM C150 – Standard Specification for Portland cement.
- D. ASTM C260 – Standard Specification for Air-Entraining Admixtures for ASTM Concrete.
- E. ASTM C361 – Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
- F. ASTM C443 – Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
- G. ASTM C655 – Standard Specification of Reinforced D-Load Culvert, Storm Drain and Sewer Pipe.
- H. ASTM C827 – Standard Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures.
- I. ASTM C924 – Standard Practice for Testing Concrete Pipe Sewer Lines by Low-Pressure Air Test Method
- J. ASTM C969 – Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
- K. ASTM C990 – Standard Specifications for Joints in Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
- L. ASTM C1103 – Standard Practice for Joint Acceptance Testing of Installed Precast Concrete Pipe Sewer Lines
- M. ASTM C1417 – Standard Specification for Reinforced Concrete Sewer, Storm Drain and Culvert Pipe for Direct Design.
- N. ASTM C1479 – Standard Practice for Installation of Precast Concrete Sewer, Storm Drain, and Culvert Pipe Using Standard Installation.
- O. ASTM C1619 – Standard Specifications for Elastomeric Seals for Joining Concrete Pipe.
- P. ASTM C1628 – Standard Specifications for Joints for Concrete Gravity Flow Sewer Pipe, Using Rubber Gaskets.
- Q. ASTM D2321 – Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications
- R. ASTM D3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals

- S. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
- T. ASTM F1417 – Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air
- U. ASTM F2487 – Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Corrugated High Density Polyethylene Pipelines
- V. ASTM F2764 – 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
- W. ASTM F2881 – Standard Specification for 12 to 60 in. [300 to 1500 mm] Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications
- X. ASTM F3058 – Standard Practice for Preliminary Field Testing of Thermoplastic Pipe Joints for Gravity Flow (Non-Pressure) Sewer Lines

1.4 Definitions

- A. PP – Polypropylene Pipe
- B. RCP – Reinforced Concrete Pipe
- C. Piping System – All products associated with the drainage system including but not limited to pipe, fittings, drainage structures, geotextile, best management practice products and storage systems.

1.5 Performance Requirements

All pipe supplied shall meet the minimum joint performance requirements as defined herein and as further defined in the joint performance requirements of this specification.

- A. Watertight Gravity-Flow, Non-Pressure, Drainage-Piping shall be in accordance with ASTM C361, ASTM C443 or ASTM C1628 for RCP, and ASTM D3212 for PP as appropriate per pipe material.
- B. Pipe fittings shall be laid so as to form a closed concentric joint with the adjoining pipe to avoid sudden offsets of the flow line. Pipe sections shall be joined together in accordance with the manufacturer’s recommendations, and in a way that they meet or exceed joint performance standards found in ASTM C361, ASTM C443 or ASTM C1628 for RCP, and ASTM D3212 for PP.

1.6 Submittals

The following shall be submitted by contractor in accordance with **Section 01 33 00 Submittal Procedures**:

- A. Product Data for the following:

1. Pipe and Fittings
 2. Product specifications
 3. Installation procedures
- B. Products submitted as approved equal must be submitted at least two (2) weeks prior to project bid opening and must be approved by project engineer. Submittal for approved equal product must contain a signed letter from an executive officer of the manufacturer stating product is equivalent to all applicable requirements of this specification.
- C. Details of fittings and specials shall be furnished for approval by ENGINEER. Unless otherwise specified, CONTRACTOR shall submit to ENGINEER for approval SHOP DRAWINGS showing the exact dimension of the joints including the permissible tolerances for each size of pipe being furnished and the size, type and locations of gasket materials. Approval of the joint detail DRAWINGS shall not relieve CONTRACTOR of any responsibilities to meet all of the requirements of these SPECIFICATIONS, or of the responsibility for correctness of CONTRACTOR's details.
- D. At the request of the ENGINEER, the CONTRACTOR shall cooperate in obtaining and providing samples of all specified materials.
- E. At the request of the ENGINEER, the CONTRACTOR shall submit certified laboratory test certificates for all items required in this section.

1.7 Delivery, Storage, and Handling

- A. All pipe and fittings shall be delivered to the site and unloaded with handling that conforms to the manufacturer's instructions for reasonable care. Pipe shall not be rolled or dragged over gravel or rock during handling. The Contractor shall take necessary precautions to ensure the method used in lifting or placing the pipe does not induce undue stress fatigue in the pipe.
- B. Responsibility for Material:
1. CONTRACTOR shall be responsible for all materials intended for the WORK that are delivered to the construction site and accepted by CONTRACTOR. Payment shall not be made for materials found to be defective or damaged in handling after delivery and acceptance. Defective or damaged materials shall be removed and replaced with acceptable materials at CONTRACTOR's expense.
 2. CONTRACTOR shall be responsible for the safe and proper storage of such materials.
- C. Pipe Acceptance:

1. RCP – In addition to any deficiencies not covered by ASTM C76 or ASTM C361 pipe which has any of the following visual defects, will not be accepted.
 - a. Pipe, which has been patched to repair porous spots, cracks, or other defects, when such patching was not approved by ENGINEER.
 - b. Exposure of the reinforcement when such exposure would indicate that the reinforcement is misplaced.
 - c. Pipe that has been damaged during shipment or from handling even if previously approved before shipment.
 - d. Concrete pipe, at delivery to the job site, shall have cured and reach the design strength as required by ASTM C76, ASTM C361 and be at least three (3) days (seventy-two [72] hours) old.

2. PP – In addition to deficiencies not covered by ASTM F2764, ASTM F2881, or AASHTO M330 pipe which has any of the following visual defects, will not be accepted.
 - a. Pipe with cracks, structural dents, or delamination, when not approved by ENGINEER.
 - b. Pipe that has been damaged during shipment or from handling even if previously approved before shipment.
 - c. Acceptance of the pipe at point of delivery shall not relieve CONTRACTOR of full responsibility for any defects in materials due to workmanship.

D. Pipe Handling:

1. Pipe and accessories furnished by CONTRACTOR shall be delivered to, unloaded, and distributed at the site by CONTRACTOR. Each pipe shall be unloaded adjacent to or near the intended laying location.
2. Pipe fittings, specials, valves, and appurtenances shall be unloaded and stored in a manner that precludes shock or damage. Such materials shall not be dropped.
3. Pipe shall be handled in a manner intended to prevent damage to the pipe ends or to any coating or lining. Pipe shall not be skidded or rolled against adjacent pipe. Damaged coatings or lining shall be repaired by CONTRACTOR, at CONTRACTOR's expense, in accordance with the recommendations of the manufacturer and in a manner satisfactory to ENGINEER. Physical damage to the pipe or accessory shall be repaired by CONTRACTOR, at

CONTRACTOR's expense, and in a manner satisfactory to ENGINEER.

4. Gasket Storage: All gaskets shall be stored in a cool place, preferably at a temperature less than seventy degrees Fahrenheit (70°F.), and in no case shall the gaskets be stored in the open, or exposed to the direct rays of the sun.

PART 2 — PRODUCTS

2.1 Corrugated Polypropylene (PP) Pipe

2.1.1 General

- A. 12-inch through 60-inch (300 through 1500 mm) pipe shall be smooth interior and annular exterior corrugated polypropylene (PP) pipe meeting the requirements of ASTM F2764, ASTM F2881 or AASHTO M330 Type S (double-wall) or D (triple-wall), for respective diameters.
- B. Material for 12- through 60-inch pipe and fitting production shall be an impact modified copolymer meeting the material requirements of ASTM F2764, ASTM F2881 and AASHTO M330, for respective pipe diameters.
- C. Marking: The following shall be clearly marked on both the interior and exterior surface of the pipe:
 1. Appropriate ASTM Specifications: ASTM F2764, ASTM F2881 or AASHTO M330; as appropriate.
 2. Class, size, and wall.
 3. Date of manufacture.
 4. Name or trademark of manufacturer.
 5. Diameter of Pipe: The diameter indicated on the DRAWINGS shall mean the inside diameter of the pipe.

2.1.2 Joint Performance

- A. Watertight joints shall be bell-and-spigot meeting the watertight requirements of ASTM D3212. Gaskets shall comply with the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable wrap to ensure the gasket is free from debris. A joint lubricant supplied by the manufacturer shall be used on the gasket and bell during assembly.

2.1.3 Fittings

- A. Fittings shall conform to ASTM F2764, ASTM F2881 or AASHTO M330, with the exception of meeting the watertight joint performance requirements of ASTM D3212. Gasketed bell & spigot connections shall utilize a spun-on, welded or integral bell and spigot with gaskets meeting ASTM F477.

- B. Repair couplers may be utilized to connect field-cut pipe.

2.2 Reinforced Concrete Pipe (RCP)

2.2.1 General

- A. Precast concrete pipe, which does not conform to ASTM C76 pipe, ASTM C361 or to any other requirement specified herein, shall not be approved for storm sewer or culvert installations.
- B. Allowable ASTM Specifications: All material, manufacturing operations, testing, inspection, and making of concrete pipe shall conform to the requirements of ASTM C76 pipe or ASTM C361, the latest revision thereof, listed in Article References.
- C. Marking: The following shall be clearly marked on both the interior and exterior surface of the pipe:
 - 1. Appropriate ASTM Specification: ASTM 76 or ASTM C361.
 - 2. Class, size, and wall.
 - 3. Date of manufacture.
 - 4. Name or trademark of manufacturer.
 - 5. Diameter of Pipe: The diameter indicated on the DRAWINGS shall mean the inside diameter of the pipe.
- D. Wall Thickness and Class of Pipe: The wall thickness and reinforcing steel, if any, shall comply with ASTM C76 for pipe or ASTM C361 and the class of pipe designated on the DRAWINGS. No elliptical reinforcing shall be allowed in any circular pipe, unless the top of the pipe is clearly noted and orientation is verified by the ENGINEER as it is being installed.

2.2.2 Joint Performance:

- A. The joint design for concrete pipe shall have a bell, spigot, and rubber gasket. The spigot shall be single offset or grooved with the gasket placed on the spigot end of the pipe. The bell and spigot shall be accurately formed so that when each pipe section forced together it shall forms a continuous watertight conduit with a smooth and uniform interior surface; and shall provide for slight movement of any piece of the pipeline due to expansion, contraction, settlement or lateral displacement. The gasket shall be the sole element of the joint providing water tightness. The ends of the pipe shall be in planes at right angles to the longitudinal centerline of the pipe. The ends shall be furnished to regular smooth surfaces.
- B. Rubber Gasketed Joints: Only rubber gasketed joints will be acceptable for concrete pipe storm sewer installations. All joints and jointing material shall conform to the following minimum requirements.

1. Rubber gasket joints for bell and spigot pipe using a confined gasket joint shall consist of a rubber gasket with an O-ring or circular cross-section and shall conform to the requirements of ASTM C361, ASTM C443, or ASTM C1628 for the designated pipe..
2. Rubber gasket joints for bell and spigot pipe using a single offset joint shall consist of a rubber gasket with a non-circular profile cross-section and shall conform to the requirements of ASTM C361, ASTM C443, or ASTM C1628 for the designated pipe..
3. Gaskets may be natural or synthetic rubber conforming to ASTM C1619.

2.2.3 Fittings

- A. Fittings shall be made up of pipe segments having the same structural qualities as the adjoining pipe and shall have the interior/exterior treated the same as the pipe.
- B. Lifting Holes: Lifting holes will be allowed for storm sewer pipe provided they are fully grouted using a non-shrink grout after installation and before backfilling the pipe. Only one lifting hole per pipe length and fitting will be allowed.
- C. Cement: Unless otherwise required by ENGINEER, or specified otherwise on the DRAWINGS, Type II Modified Portland Cement complying with the requirements of ASTM C150 will normally be acceptable in the manufacture of concrete pipe.

PART 3 — EXECUTION

3.1 Earthwork

- A. Excavation, trenching, and backfilling shall be as specified in **Section 31 23 00, Excavation and Fill**.

3.2 Identification

- A. For all stormwater gravity piping, install warning tape directly over pipe and at outside edges of underground structures. Detectable warning tape shall be installed over storm drainage piping and over edges of underground structures.

3.3 Piping Inspection

3.3.1 General

- A. Piping, fittings, and drainage structures shall be inspected prior to installation and any defective or damaged product shall be replaced.
- B. Refer to Section 1.7 Delivery, Storage and Handling for pipe & fitting acceptance requirements

3.3.2 Inspection

- A. Any pipe, fittings, or drainage structures with cracks, cuts, punctures, or other damage on the interior or exterior shall be rejected and replaced.
- B. Any pipe, fittings or drainage structures with damaged ends, joints or gaskets, which would prevent proper sealing of the joints, shall be rejected and replaced.
- C. The pipe shall be inspected by ENGINEER for damage or defects before being placed in the trench. Damaged or defective pipe shall not be installed.
- D. All pipes that do not meet the requirements of PART 2 of this section will be rejected and replaced at CONTRACTOR's expense.

3.4 Piping, Fitting, and Drainage Structure Installation

3.4.1 General

- A. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of stormwater gravity piping. Location and arrangement of piping layout take design considerations into account. Install piping system as indicated herein and as directed by the product manufacturer, to extent practical. Where specific installation procedure is not indicated, follow product manufacturer's written instructions.
- B. All products shall be inspected for defects and cracks before being lowered into the trench, piece by piece. Any defective, damaged or unsound pipe, fitting or drainage structure or any product that has had its grade disturbed after laying, shall be taken up and replaced. Open ends shall be protected with a pipe plug to prevent earth or other material from entering the pipe during construction. The interior of the pipe shall be free from dirt, excess water and other foreign materials as the pipe laying progresses and left clean at the completion of the installation.
- C. Install piping system beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions. Follow product manufacturer's instructions for the use of lubricants, cements, and other special installation requirements.
- D. Use Manholes or Catch Basins for changes in direction, unless fittings are indicated. Use tap-fittings for branch connections, unless fittings are specified on the drawings.
- E. Use proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
- F. For RCP, CONTRACTOR shall install storm sewer pipe of the type, diameter, load class, and wall thickness that is shown on the

DRAWINGS. Installation shall be in accordance with Section 27 of The AASHTO LRFD Bridge Construction Specifications or ASTM C1479.

- G. For PP, CONTRACTOR shall install storm sewer pipe of the type, diameter, and joint performance that is shown on the DRAWINGS. Installation shall be in accordance with Section 30 of The AASHTO LRFD Bridge Construction Specifications, ASTM D2321, or manufacture recommendations.
- H. Proper equipment, implements, tools and facilities shall be provided and used by CONTRACTOR for safe and convenient installation of the type of pipe being installed.

3.4.2 Trench Excavation

3.4.2.1 Excavation

- A. Within Easement, Cultivated, Landscaped, or Agricultural Area:
 - 1. All vegetation, such as brush, sod, heavy growth of grass or weeds, decayed vegetable matter, rubbish and other unsuitable material within the area of excavation and trench side storage shall be stripped and disposed of in accordance with the requirements of **Section 31 11 00, Clearing and Grubbing**.
 - 2. Within Unpaved Roadway Areas: CONTRACTOR shall strip the cover material from graveled roadways or other developed, but unpaved traffic surfaces to the full depth of the existing surfacing. The surfacing shall be stockpiled to the extent that it is acceptable and useable for restoration purposes.
- B. Within Paved Areas:
 - 1. The removal of pavement, sidewalks, driveways, or curb and gutter shall be performed in a neat and workmanlike manner. Concrete pavement, asphalt, sidewalks, driveways, or curb and gutter shall be cut with a power saw to a depth of two (2) inches prior to breaking. The concrete shall be cut vertically in straight lines and avoiding acute angles.
 - 2. Bituminous pavement, sidewalks, driveways, or curb and gutter shall be cut with a power saw, pavement breaker, or other approved method of scoring the mat prior to breaking or excavation. The bituminous mat shall be cut vertically, in straight lines and avoiding acute angles.
 - 3. Any overbreak, separation, or other damage to the existing bituminous or concrete outside the designated cut lines shall be replaced at CONTRACTOR's expense.
 - 4. Excavated paving materials shall be removed from the job site and shall not be used as fill or backfill.
- C. Excavate trenches to ensure that sides will be stable under all working conditions. Slope trench walls or provide supports in conformance with

all local and national standards for safety. Open only as much trench as can be safely maintained by available equipment. Backfill all trenches as soon as practicable, but not later than the end of each working day.

- D. Where trench walls are stable or supported, provide a width sufficient, but no greater than necessary, to ensure working room to properly and safely place and compact haunching and other embedment materials. The space between the pipe and trench wall must be wider than the compaction equipment used in the pipe zone. In addition to safety considerations, trench width in unsupported, unstable soils will depend on the size and stiffness of the pipe, stiffness of the embedment and in-situ soil, and depth of cover.
 - 1. For PP, minimum trench width shall be not less than the greater of either the pipe outside diameter plus 16 in. or the pipe outside diameter times 1.25, plus 12 in. or in accordance with ASTM D2321.
 - 2. For RCP, minimum clearance between pipe and trench wall shall be wide enough to ensure specified compaction of backfill material, but not less than outside diameter divided by 6 or in accordance with ASTM C1479.
- E. Where trench walls or sub-grade are not stable or consist of unsuitable material, trench shall be widened as required in ASTM D2321 or ASTM C1479 as appropriate per material. Trench widths may be widened up to three diameters wide and subgrade increased to one half pipe diameter or as required by ENGINEER.
- F. When supports such as trench sheeting, trench jacks, trench shields or boxes are used, ensure that support of the pipe and its embedment is maintained throughout installation. Ensure that sheeting is sufficiently tight to prevent washing out of the trench wall from behind the sheeting. Provide tight support of trench walls below viaducts, existing utilities, or other obstructions that restrict driving of sheeting.

3.4.2.2 Dewatering

- A. All pipe trenches and excavation for structures and appurtenances shall be kept free of water during pipe laying and other related work. The method of dewatering shall provide for a dry foundation at the final grades of excavation in accordance with **Section 31 23 19, Dewatering**. Water shall be disposed of in a manner that does not inconvenience the public or result in a menace to public health. Pipe trenches shall contain enough backfill to prevent pipe flotation before dewatering is discontinued. Dewatering shall continue until such time as it is safe to allow the water to rise in the excavation.
- B. Do not lay or embed pipe fittings or drainage structures in standing or running water. At all times prevent runoff and surface water from entering the trench.
- C. When water is present in the work area, dewater to maintain stability of in-situ and imported materials. Maintain water level below pipe bedding

and foundation to provide a stable trench bottom. Use, as appropriate, sump pumps, well points, deep wells, geotextile fabrics, perforated underdrains, or stone blankets of sufficient thickness to remove and control water in the trench. When excavating while depressing ground water, ensure the ground water is below the bottom of cut at all times to prevent washout from behind sheeting or sloughing of exposed trench walls. Maintain control of water in the trench before, during, and after pipe system installation and until embedment is installed and sufficient backfill has been placed to prevent flotation of the pipe, fitting, or drainage structures. To preclude loss of soil support, employ dewatering methods that minimize removal of fines and the creation of voids in in-situ materials.

3.4.2.3 Removal of Rock

- A. Rock in either ledge or boulder formation shall be replaced with suitable materials to provide a compacted earth cushion having a thickness between exposed rock and the pipe of at least six inches or as required by ENGINEER. 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 under **Section 31 00 00 Earthwork**.

3.4.2.4 Removal of Unstable Material

- A. Where wet or otherwise unstable soil incapable of properly supporting the pipe system, as determined by the Engineer, is encountered in the bottom of a trench, such material shall be removed to at least 24 inches below bottom of pipe and replaced to the proper grade with select granular material, compacted as directed by the ENGINEER. 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 Owner.
- B. Where trench walls or sub-grade are not stable or consist of unsuitable material, trench shall be widened as required in ASTM D2321 or ASTM C1479 as appropriate per material. Trench widths may be widened up to three diameters wide and subgrade increased to one half pipe diameter or as required by ENGINEER.

3.4.3 Installation

- A. General: Precautions shall be taken to prevent foreign material from entering the pipe before or while it is being placed in the line. During laying operations, no debris, tools, clothing or other materials shall be placed in the pipe. The open ends of pipe shall be closed with a plug, or with other devices approved by ENGINEER, at times when pipe laying is not in progress.

B. Pipe

1. Storm sewer pipe shall be installed in accordance with ASTM C1479 (RCP) or ASTM D2321 (PP), the manufacturer's

recommendations for installing the type of pipe used, and what is shown on the DRAWINGS.

2. Pipe lines shall be laid to the grades and alignment shown on the DRAWINGS and as staked by ENGINEER. Variation from the prescribed grade and alignment shall not be allowed unless approved by ENGINEER.
3. RCP with lifting holes shall be installed such that the lifting holes are in the crown of the pipe. All lifting holes shall be properly grouted with non-shrink grout immediately after the pipe is installed and prior to commencement of backfilling. Lift hole grouting shall be inspected and approved by the ENGINEER immediately after the pipe is installed and prior to commencement of backfilling.

C. Pipe Fittings:

1. For RCP, fittings shall be laid so as to form a closed concentric joint with the adjoining pipe to avoid sudden offsets of the flow line. Pipe sections shall be joined together in accordance with the manufacturer's recommendations, and in a way that they meet or exceed performance standards found in ASTM C361, ASTM C443, or ASTM C1628.
2. For PP, fittings shall be laid so as to form a closed concentric joint with the adjoining pipe to avoid sudden offsets of the flow line. Pipe sections shall be joined together in accordance with the manufacturer's recommendations, and in a way that they meet or exceed performance standards found in ASTM F2764, ASTM F2881 or AASHTO M330.
3. Pipe fittings and appurtenances shall be carefully lowered into the trench with suitable tools or equipment to prevent damage to the pipe and protective coatings and linings; pipe and accessory materials shall not be dropped or dumped into the trench.

D. Gaskets: No gaskets that show signs of deterioration, such as surface cracking or checking, shall be installed in a pipe joint. Gaskets that sustain damage during the installation process shall be removed, discarded and replaced per the manufacturer's guidelines.

E. Obstructions not shown on the DRAWINGS may be encountered during the progress of the WORK. Should such an obstruction require an alteration to pipe alignment or grade, ENGINEER will have authority to order a deviation from the DRAWINGS, or ENGINEER may arrange for the removal, relocation, or reconstruction of any structure, which obstructs the pipeline.

3.4.4 Bedding

A. A stable and uniform bedding shall be provided for the pipe and any protruding features of its joint and/or fittings. The middle of the bedding, equal to one-third of the pipe outside diameter, shall be loosely placed while the remainder shall be compacted to a minimum of 90% of

maximum density per AASHTO T99, or as shown in the plans. Pipe bedding shall be a minimum of 4 – 6 inches in thickness or as required on the plans.

- B. The bedding surface for the pipe shall provide a firm foundation of uniform density throughout the entire length of the pipe, and extend a minimum of 12 inches beyond the end of the pipe being laid.

3.4.5 Placing Pipe

- A. Each pipe shall be thoroughly examined before being laid; defective or damaged pipe shall not be used. Refer to Section 1.7 Delivery, Storage and Handling for pipe & fitting acceptance requirements.
- B. Pipelines shall be laid to the grades and alignment indicated.
- C. Proper facilities shall be provided for lowering sections of pipe into trenches.
- D. Pipe shall not be laid in water, and the pipe shall not be laid when trench conditions or weather are unsuitable for such work. Diversion of drainage or dewatering of trenches shall be provided as directed by the engineer; see dewatering section.
- E. Where outside diameter of bell exceeds outside diameter of pipe, care shall be taken to ensure adequate bedding material is moved to accommodate the difference of diameter and provide support to the entire joint and length of pipe.

3.4.6 Jointing

- A. Joints shall be constructed as described herein and in accordance with manufacturer's installation instructions.
- B. All Bell-and-Spigot pipe joints shall be thoroughly cleaned prior to joining.
- C. Protective gasket wrap must be removed just prior to joint insertion to reduce the risk of introduction of foreign materials.
- D. Joints with gaskets not pre-installed by the manufacturer must be clean and free of foreign materials prior to gasket installation.
- E. Joint lubricant, supplied by the manufacturer, shall be applied to the interior of bell and the leading edge of the gasket on spigot prior to assembly.
- F. Joints shall be assembled by inserting the spigot into the bell to prevent foreign materials from being trapped in the joint connection.
- G. After initial assembly of the joint, CONTRACTOR shall verify line and grade of pipe. Prior to backfill and after final check of line and grade, the CONTRACTOR must verify the joint is fully inserted and properly sealed.

3.4.7 Backfilling

3.4.7.1 General

Backfill placement and compaction shall be constructed in accordance with the specifications herein and the product manufacturer's published installation guides

3.4.7.2 Backfilling Pipe in Trenches

- A. Backfill shall be placed in accordance with ASTM D2321 (PP) and ASTM C1479 (RCP).
- B. After the pipe has been laid on the bedding and is ready for backfill. Appropriate backfill at moisture content that will facilitate compaction, shall be placed in layers along both sides of the pipe at depths to ensure specified density is achieved evenly throughout the backfill material. Prior to compaction, backfill shall be placed under the haunches of the pipe.
- C. Appropriate compaction methods shall be utilized in order to uniformly compact backfill to specified densities. Inappropriate or excessive compaction may damage the pipe and disturb line and grade.
- D. Each layer shall be uniformly compacted with mechanical means. Backfill and compaction shall continue until fill has reached an elevation of at least 6 inches above the top of the pipe. **The remainder of the trench shall be backfilled and compacted as noted on the plans or as directed by the ENGINEER.**
- E. Tests for density shall be made as directed by the ENGINEER to ensure conformance to the compaction requirements specified below.
- F. Where it is necessary, in the opinion of the ENGINEER, 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.

3.4.7.3 Backfilling Pipe in Fill Sections

- A. Select bedding and backfill material may be required and shall be so shown on the construction drawings.
- B. For pipe placed in fill sections, fill shall be constructed to at least 6 inches above the top of proposed pipe prior to trench excavation. Bedding shall be distributed in six-inch (6") maximum layers over the full width of the trench and simultaneously on both sides of the pipe. Special care shall be taken to ensure full compaction under the haunches and joints of the pipe. Fill shall be placed in 12 inch lifts and shall be compacted to achieve 90% of maximum density, or as shown on plans. **Once fill is placed and compacted pipe trench shall be constructed in accordance with 3.4.7.2 Backfilling Pipe in Trenches.**
- C. PP - Bedding and backfill materials shall conform to an ASTM D2321, unless approved in writing by the ENGINEER. Special attention shall

be made to ensure based on an ASTM D2321 that fill over the pipe falls within the manufacturer's and ENGINEER's allowable limits.

- D. RCP - Bedding and backfill shall conform to an ASTM C1479 Type I, II, or III installation, unless approved in writing by the ENGINEER. Special attention shall be made to ensure based on an ASTM C1479 Type I, II or III installation that fill over the pipe falls within the manufacturer's and ENGINEER's allowable limits.

3.4.7.4 Compaction

A. General Requirements

Non-cohesive 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, silts, and very fine sands. Non-cohesive soils consolidate best with vibratory compaction. Cohesive soils consolidate with equipment that kneads the soil in place. Backfill must be compacted with appropriate equipment to ensure the backfill uniformly consolidates to specified limits, without causing damage to or movement in the pipe during compaction operations.

B. Minimum Density

1. Backfill around pipe and structures shall be compacted at a +2.0% of optimum moisture content to densities listed below, or as directed by ENGINEER.
2. 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 95 percent of standard proctor density for cohesive material and 90 percent of standard proctor density for non-cohesive material, up to the elevation where requirements for pavement subgrade materials and compaction shall control.
3. Under area without paved surfaces all soils shall be consolidated to a minimum 90 percent standard proctor density, unless specifically called out otherwise on the drawings.

3.4.7.5 Determination of Density

Testing shall be the responsibility of the CONTRACTOR and performed at no additional cost to the Owner. Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval by the Engineer. 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 shall 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 D2922. When ASTM D2922 is used, the calibration curves shall be checked and adjusted, if necessary, using the sand cone method as described in

the Calibration paragraph of the referenced publications. ASTM D2922 results in a wet unit weight of soil and when using this method ASTM D3017 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 D3017 or ASTM D2922. Test results shall be furnished to the Engineer. 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

3.4.7.6 Construction Equipment and Compaction 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

3.5 Testing and Inspection

3.5.1 General

- A. Following the placement and densification of backfill and prior to the placing of the permanent pavement, all pipes shall be cleaned, and inspected with CCTV. Where damage or poorly installed pipe is observed the pipe shall be tested for leakage, have crack's length and width quantified, joint gaps and offsets measured, and deflection verified; unless otherwise specified by the ENGINEER.

3.5.2 Television Inspection (CCTV)

- A. A closed circuit television (CCTV) inspection shall be conducted prior to new storm drain pipeline acceptance. The Inspection shall document and verify the following: The overall condition of the host pipeline, Line and Grade, Cleanliness, Joints, Cracks, and any other observed damage to the inside of the pipe.
- B. The inspection will be used to evaluate issues that may affect long-term performance of the system. Evaluations on installed pipe shall be conducted per the AASHTO LRFD Bridge Construction Specification, Section 27 (RCP) and Section 30 (PP).
- C. The inspection shall occur no sooner than 30-days after backfill reaches subgrade, unless approved by the ENGINEER.
- D. The operator shall be trained and competent at operating equipment, taking accurate measurements, and identifying all items required to be noted in the inspection report.
- E. Cleaning of the storm drains shall be performed prior to the television inspection.
- F. The Contractor shall perform a television inspection (CCTV) on all storm drains between manholes and all storm drain inlet laterals at a speed no faster than 30 feet per minute using a Camera with high

definition resolution, minimum one lux, 10x optical zoom, 10x digital zoom, and a lighting system that is sufficient to clearly illuminate a 60" diameter pipe 10 feet in front of the camera. Pipe runs shall be continuously measured from one pipe end to the other.

- G. All joints shall be inspected with the camera stopping and rotating around the entire joint. The CCTV camera shall be centered in the pipe, have the ability to pan to a true 90 degrees from the pipe wall and rotate 360 degrees to fully view joints and any observed surface damage.
- H. Joint separation greater than 0.5-inch, cracking greater than 0.01-inch, deflection over 5%, infiltration, or other noted damage inside the pipe may justify additional inspection, as directed by the ENGINEER.
- I. The camera's inspection systems shall be capable of accurately identifying the systems x, y, and z location in the pipe. Pipe length, diameter, location, location of noted items, photos of noted items, and a description of noted items shall all be documented and included in the inspection report. The system shall also have a GPS with sub meter accuracy so all manholes and other surface structures can be located and noted in the final report.
- J. All data shall be provided digitally and provided in a final report to the OWNER, CONTRACTOR, and ENGINEER.

3.5.3 Tests for Deflection

- A. When visual inspection or inspection by CCTV indicates a potential for excessive deflection, the following test method shall be used.
- B. Deflection tests shall be made by the contractor upon completion and acceptance of backfill operations to finish subgrade, and prior to placement of the finished surface, if any. The deflection testing shall be witnessed by the Inspector and shall be conducted by the CONTRACTOR at the CONTRACTOR'S expense. Deflection shall be tested for excessive vertical deflection using a mandrel approved by the agency. The mandrel shall be sized so as to provide a diameter of at least 95% of the allowable minimum inside diameter. Elbow and wye type fittings should not have a mandrel pulled through them.
- C. Pipe 36" or larger may be direct measured provided the appropriate safety equipment and certifications are use and held by the inspectors.
- D. Laser profiling equipment may be used instead of pulling mandrels. All laser profiled results are subject to verification by mandrel or direct measurement.

3.5.4 Measuring Cracks and Open Joints

- A. For RCP, joints separated by more than 0.5-inch and cracks wider than 0.01-inch shall be accurately measured and noted in the inspection report. If camera optics and on board measuring device is not capable of accurately measuring down to 0.01" then the system shall not be used, unless approved by the ENGINEER.
- B. For PP, joints separated by more than the manufacturers' allowable tolerance shall be accurately measured and noted in the inspection report and repaired by the CONTRACTOR as directed by the manufacturer. If camera optics and on board measuring device is not capable of accurately measuring down to 0.01" then the system shall not be used, unless approved by the ENGINEER.
- C. Pipe 36" and larger may have joints and cracks directly measured using a tape measure for joints gaps and crack lengths, and a feeler gauge for crack widths. Photos of damage should be taken, with locations of each measurement located relative to the pipe ends.

3.5.5 Tests for Leakage

- A. When visual inspection or inspection by CCTV indicates a potential for leakage through cracks, at joints rated to be watertight, or if the ENGINEER requires testing; the one of the following test methods shall be used to field verify the systems leakage performance.

3.5.5.1 Corrugated Polypropylene (PP) Pipe Leakage Tests

- A. Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests, as appropriate.
- B. Low pressure air testing shall conform to ASTM F1417. When leakage exceeds the maximum amount specified, satisfactory correction, as approved by the Engineer, shall be made and retesting accomplished.
- C. Infiltration and exfiltration testing shall conform to ASTM F2487. Prior to exfiltration tests, the pipe shall be completely backfilled. Visible leaks encountered during CCTV or other operations shall be corrected regardless of leakage test results. When leakage exceeds the maximum amount specified, satisfactory correction, as approved by the Engineer, shall be made and retesting accomplished.
- D. In lieu of low pressure air testing and infiltration/exfiltration testing in Sections B and C above, joint isolation testing of each joint may be performed in accordance with ASTM F3058.

3.5.5.2 Reinforced Concrete Pipe (RCP) Leakage Tests

- A. Lines shall be tested for leakage by low pressure air or water testing or exfiltration tests, as appropriate.
- B. Low pressure air testing shall conform to ASTM C924. When leakage exceeds the maximum amount specified, satisfactory

correction, as approved by the Engineer, shall be made and retesting accomplished.

- C. Infiltration and exfiltration testing shall conform to ASTM C969 for RCP. Prior to exfiltration tests, the pipe shall be completely backfilled. Visible leaks encountered during CCTV or other operations shall be corrected regardless of leakage test results. When leakage exceeds the maximum amount specified, satisfactory correction, as approved by the Engineer, shall be made and retesting accomplished.
- D. In lieu of low pressure air testing and infiltration/exfiltration testing in Sections B and C above, joint isolation testing of each joint may be performed in accordance with ASTM C1103 .

END OF SECTION