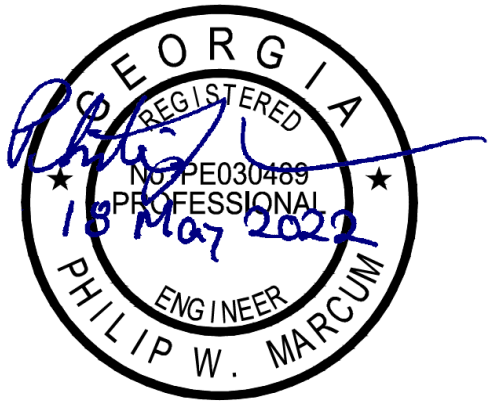
SECTION 31 00 00

EARTHWORK

APPROVAL STATUS							
PREPARED BY:	PWM	**DATE**	17 May 2022	**CHECKED BY:**	DWD	**DATE**	17 May 2022
APPROVED BY:	PWM	**DATE**	17 May 2022				

REVISION STATUS						
REV	**ISSUED FOR**	**REVISED BY**	**CHECKED BY**	**APPROVAL**	**APPROVAL**	**DATE**
0	Permits					

Engineer's Seal



SECTION 31 00 00

EARTHWORK

PART 1 GENERAL

1.1 SCOPE

The work in this section includes furnishing all labor, equipment, materials and supervision required to perform earthwork and grading as shown on the contract drawings and as specified herein. Said work shall include, but not be limited to, the following items:

Excavation and filling of the subgrade for walks, paved areas, building sites, roadways, track roadbeds, and other areas;

Finish grading of cut and fill areas;

Excavation and disposal of muck, rock and other materials considered unsuitable for building purposes;

Excavation of select borrow or backfill, transporting the material and stockpiling and spreading it.

1.2 REFERENCES

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 T 180	(2017) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances

ASTM INTERNATIONAL (ASTM)

ASTM C33/C33M	(2018) Standard Specification for Concrete Aggregates
ASTM C136/C136M	(2019) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D698	(2012; E 2014; E 2015) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

ASTM D1140	(2017) Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing
ASTM D1556/D1556M	(2015; E 2016) Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
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 D2167	(2015) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2434	(1968; R 2006) Permeability of Granular Soils (Constant Head)
ASTM D2487	(2017; E 2020) Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D2937	(2017; E 2017; E 2018) Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
ASTM D4318	(2017; E 2018) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4718/D4718M	(2015) Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D6938	(2017a) Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

U.S. ARMY CORPS OF ENGINEERS (USACE)

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

U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA)

EPA 600/4-79/020	(1983) Methods for Chemical Analysis of Water and Wastes
EPA SW-846.3-3	(1999, Third Edition, Update III-A) Test Methods for Evaluating Solid Waste: Physical/Chemical Methods

1.3 DEFINITIONS

1.3.1 Satisfactory Materials

Satisfactory materials comprise any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, CL, ML, CL-ML, CH, MH. Satisfactory materials for grading comprise stones less than 8 inches, except for fill material for pavements and railroads which comprise stones less than 3 inches in any dimension.

1.3.2 Unsatisfactory Materials

Materials which do not comply with the requirements for satisfactory materials are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; and material classified as satisfactory which contains root and other organic matter or frozen material. Notify the Geotechnical Engineer when encountering any contaminated materials.

1.3.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are nonplastic. Perform testing, required for classifying materials, in accordance with ASTM D4318, ASTM C136/C136M and ASTM D1140.

1.3.4 Degree of Compaction

Degree of compaction required, except as noted in the second sentence, is expressed as a percentage of the maximum density obtained by the test procedure presented in ASTM D1557 and ASTM D698 abbreviated as a percent of laboratory maximum density. Since ASTM D1557 applies only to soils that have 30 percent or less by weight of their particles retained on the 3/4 inch sieve, express the degree of compaction for material having more than 30 percent by weight of their particles retained on the 3/4 inch sieve as a percentage of the maximum density in accordance with AASHTO T 180 and corrected with ASTM D4718/D4718M.

1.3.5 Topsoil

Material suitable for topsoils obtained from offsite areas excavations areas indicated on the drawings is defined as: Natural, friable soil representative of productive, well-drained soils in the area, free of subsoil, stumps, rocks larger than one inch diameter, brush, weeds, toxic substances, and other material detrimental to plant growth. Amend topsoil pH range to obtain a pH of 5.5 to 7.

1.3.6 Hard/Unyielding Materials

Hard/Unyielding materials comprise weathered rock, dense consolidated deposits, or conglomerate materials which are not included in the definition of "rock" with stones greater than 3 inches in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

1.3.7 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges, or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 1/2 cubic yard in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

1.3.8 Unstable Material

Unstable materials are too wet to properly support the utility pipe, conduit, or appurtenant structure.

1.3.9 Select Granular Material

1.3.9.1 General Requirements

Select granular material consist of materials classified as GW, GP, SW, SP, by ASTM D2487 where indicated. The liquid limit of such material must not exceed 35 percent when tested in accordance with ASTM D4318. The plasticity index must not be greater than 12 percent when tested in accordance with ASTM D4318, and not more than 35 percent by weight may be finer than No. 200 sieve when tested in accordance with ASTM D1140

1.3.10 Initial Backfill Material

Initial backfill consists of select granular material or satisfactory materials free from rocks 3 inches or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller.

1.3.11 Pile Supported Structure

As used herein, a structure where both the foundation and floor slab are pile supported.

1.4 SYSTEM DESCRIPTION

Subsurface soil boring logs are attached. Additional borings are in production and the data will be provided under separate cover. These data represent the best subsurface information available; however, variations may exist in the subsurface between boring locations.

1.4.1 Classification of Excavation

No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation. Finish the specified excavation on a classified basis, in accordance with the following designations and classifications.

1.4.1.1 Common Excavation

Include common excavation with the satisfactory removal and disposal of all materials not classified as rock excavation.

1.4.1.2 Rock Excavation

Submit notification of encountering rock in the project. Include rock excavation with blasting, excavating, grading, disposing of material classified as rock, and the satisfactory removal and disposal of boulders 1/2 cubic yard or more in volume; solid rock; rock material that is in ledges, bedded deposits, and unstratified masses, which cannot be removed without systematic drilling and blasting; firmly cemented conglomerate deposits possessing the characteristics of solid rock impossible to remove without systematic drilling and blasting; and hard materials (see Definitions). Include the removal of any concrete or masonry structures, except pavements, exceeding 1/2 cubic yard in volume that may be encountered in the work in this classification. If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock excavation, uncover such material and notify the Geotechnical Engineer. Do not proceed with the excavation of this material until the Geotechnical Engineer has classified the materials as common excavation or rock excavation and has taken cross sections as required. Failure on the part of the Contractor to uncover such material, notify the Geotechnical Engineer, and allow ample time for classification and cross sectioning of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Geotechnical Engineer for the areas of work in which such deposits occur.

1.4.2 Blasting

Geotechnical Engineer blasting will not be permitted.

1.4.3 Dewatering Work Plan

Submit procedures for accomplishing dewatering work.

1.5 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Shoring;

Dewatering Work Plan;

SD-03 Product Data

Utilization of Excavated Materials;

Rock Excavation

Opening of any Excavation or Borrow Pit

Shoulder Construction

SD-06 Test Reports

Testing

Borrow Site Testing

Within 24 hours of conclusion of physical tests, submit six copies of test results, including calibration curves and results of calibration tests.

SD-07 Certificates

Testing

PART 2 PRODUCTS

2.1 REQUIREMENTS FOR OFFSITE SOILS

Test offsite soils brought in for use as backfill for Total Petroleum Hydrocarbons (TPH), Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and full Toxicity Characteristic Leaching Procedure (TCLP) including ignitability, corrosivity and reactivity. Backfill shall contain a maximum of 100 parts per million (ppm) of total petroleum hydrocarbons (TPH) and a maximum of 10 ppm of the sum of Benzene, Toluene, Ethyl Benzene, and Xylene (BTEX) and shall pass the TCPL test. Determine TPH concentrations by using EPA 600/4-79/020 Method 418.1. Determine BTEX concentrations by using EPA SW-846.3-3 Method 5030/8020. Perform TCLP in accordance with EPA SW-846.3-3 Method 1311. Provide Borrow Site Testing for TPH, BTEX and TCLP from a composite sample of material from the borrow site, with at least one test from each borrow site. Do not bring material onsite until tests have been approved by the Geotechnical Engineer.

2.2 BURIED WARNING AND IDENTIFICATION TAPE

Provide polyethylene plastic and metallic core or metallic-faced, acid- and alkali-resistant, polyethylene plastic warning tape manufactured specifically for warning and identification of buried utility lines. Provide tape on rolls, 3 inches minimum width, color coded as specified below for the intended utility with warning and identification imprinted in bold black letters continuously over the entire tape length. Warning and identification to read, "CAUTION, BURIED (intended service) LINE BELOW" or similar wording. Provide permanent color and printing, unaffected by moisture or soil.

Sieve Size	Percent Passing by Weight
2-1/2 inches	100
No. 4	40 - 85
No. 10	20 - 80
No. 40	10 - 60
No. 200	5 - 25

2.2.1 Warning Tape for Metallic Piping

Provide acid and alkali-resistant polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.003 inch and a minimum strength of 1500 psi lengthwise, and 1250 psi crosswise, with a maximum 350 percent elongation.

2.2.2 Detectable Warning Tape for Non-Metallic Piping

Provide polyethylene plastic tape conforming to the width, color, and printing requirements specified above, with a minimum thickness of 0.004 inch, and a minimum strength of 1500 psi lengthwise and 1250 psi crosswise. Manufacture tape with integral wires, foil backing, or other means of enabling detection by a metal detector when tape is buried up to 3 feet deep. Encase metallic element of the tape in a protective jacket or provide with other means of corrosion protection.

2.3 DETECTION WIRE FOR NON-METALLIC PIPING

Insulate a single strand, solid copper detection wire with a minimum of 12 AWG.

2.4 MATERIAL FOR RIP-RAP

Provide Bedding material, Filter fabric and rock conforming to GA DOT Standards and Specifications for construction indicated.

2.4.1 Bedding Material

Provide bedding material consisting of sand, gravel, or crushed rock, well graded, or poorly graded with a maximum particle size of 2 inches. Compose material of tough, durable particles. Allow fines passing the No. 200 standard sieve with a plasticity index less than six.

2.4.2 Rock

Provide rock fragments sufficiently durable to ensure permanence in the structure and the environment in which it is to be used. Use rock fragments free from cracks, seams, and other defects that would increase the risk of deterioration from natural causes. Provide fragments sized so that no individual fragment exceeds a weight of 150 pounds and that no more than 10 percent of the mixture, by weight, consists of fragments weighing 2 pounds or less each. Provide rock with a minimum specific gravity of 2.50. Do not permit the inclusion of more than trace 1 percent quantities of dirt, sand, clay, and rock fines.

2.5 CAPILLARY WATER BARRIER

Provide capillary water barrier of clean, poorly graded crushed rock, crushed gravel, or uncrushed gravel placed beneath a building slab with or without a vapor barrier to cut off the capillary flow of pore water to the area immediately below. Conform to ASTM C33/C33M for fine aggregate grading with a maximum of 3 percent by weight passing ASTM D1140, No. 200 sieve, or 1-1/2 inch and no more than 2 percent by weight passing the No. 4 size sieve or coarse aggregate Size 57, 67, or 77.

PART 3 EXECUTION

3.1 STRIPPING OF TOPSOIL

Where indicated or directed, strip topsoil to a depth of 6 inches. Spread topsoil on areas already graded and prepared for topsoil, or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. Keep topsoil separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 2 inches in diameter, and other materials that would interfere with planting and maintenance operations. Stockpile in locations indicated any surplus of topsoil from excavations and gradings.

3.2 GENERAL EXCAVATION

Perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated and as specified. Perform the grading in accordance with the typical sections shown and the tolerances specified in paragraph FINISHING. Transport satisfactory excavated materials and place in fill or embankment within the limits of the work. Excavate unsatisfactory materials encountered within the limits of the work below grade and replace with satisfactory materials as directed. Include such excavated material and the satisfactory material ordered as replacement in excavation. Dispose surplus satisfactory excavated material not required for fill and unsatisfactory excavated material as specified in paragraph DISPOSITION OF SURPLUS MATERIAL. During construction, perform excavation and fill in a manner and sequence that will provide proper drainage at all times. Excavate material required for fill or embankment in excess of that produced by excavation within the grading limits from the borrow areas indicated or from other approved areas selected by the Contractor as specified.

3.2.1 Ditches, Gutters, and Channel Changes

Finish excavation of ditches, gutters, and channel changes by cutting accurately to the cross sections, grades, and elevations shown on the Construction Drawings. Do not excavate ditches and gutters below grades shown. Backfill the excessive open ditch or gutter excavation with satisfactory, thoroughly compacted, material or with suitable stone or cobble to grades shown. Dispose excavated material as shown or as directed, except in no case allow material be deposited a maximum 4 feet from edge of a ditch. Maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

3.2.2 Drainage Structures

Make excavations to the lines, grades, and elevations shown, or as directed. Provide trenches and foundation pits of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or other hard foundation material of loose debris and cut to a firm, level, stepped, or serrated surface. Remove loose disintegrated rock and thin strata. Do not disturb the bottom of the excavation when concrete or masonry is to be placed in an excavated area. Do not excavate to the final grade level until just before the concrete or masonry is to be placed. Where pile foundations are to be used, stop the excavation of each pit at an elevation 1 foot above the base of the footing, as specified, before piles are driven. After the pile

driving has been completed, remove loose and displaced material and complete excavation, leaving a smooth, solid, undisturbed surface to receive the concrete or masonry.

3.2.3 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. Construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and or provide temporary ditches, swales, and other drainage features and equipment as required to maintain dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

3.2.4 Dewatering

Control groundwater flowing toward or into excavations to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. Do not permit French drains, sumps, ditches or trenches within 3 feet of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Take control measures by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, maintain the water level continuously, at least 3 feet below the working level. Operate dewatering system continuously until construction work below existing water levels is complete. Submit performance records weekly. Measure and record performance of dewatering system at same time each day by use of observation wells or piezometers installed in conjunction with the dewatering system. Relieve hydrostatic head in previous zones below subgrade elevation in layered soils to prevent uplift.

3.2.5 Trench Excavation Requirements

Excavate the trench as recommended by the manufacturer of the pipe to be installed. Slope trench walls below the top of the pipe, or make vertical, and of such width as recommended in the manufacturer's printed installation manual. Provide vertical trench walls where no manufacturer's printed installation manual is available. Shore trench walls, cut back to a stable slope, or provide with equivalent means of protection for employees who may be exposed to moving ground or cave in, as determined by the Contractor’s Safety Engineer or other competent person; refer to USACE publication EM 385-1-1. Excavate trench walls which are cut back to at least the angle of repose of the soil. Give special attention to slopes which may be adversely affected by weather or moisture content. Do not exceed the trench width below the pipe top of 24 inches plus pipe outside diameter (O.D.) for pipes of less than 24 inches inside diameter, and do not exceed 36 inches plus pipe outside diameter for sizes larger than 24 inches inside diameter. Where recommended trench widths are exceeded, provide redesign, stronger

pipe, or special installation procedures by the Contractor. The Contractor is responsible for the cost of redesign, stronger pipe, or special installation procedures without any additional cost to the Government.

3.2.5.1 Bottom Preparation

Grade the bottoms of trenches accurately to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Excavate bell holes to the necessary size at each joint or coupling to eliminate point bearing. Remove stones of 4 inch or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, to avoid point bearing.

3.2.5.2 Removal of Unyielding Material

Where overdepth is not indicated and unyielding material is encountered in the bottom of the trench, remove such material 12 inches below the required grade and replaced with suitable materials as provided in paragraph BACKFILLING AND COMPACTION.

3.2.5.3 Removal of Unstable Material

Where unstable material is encountered in the bottom of the trench, remove such material to the depth directed and replace it to the proper grade with select granular material as provided in paragraph BACKFILLING AND COMPACTION. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the Contractor is responsible for excavating the resulting material and replacing it without additional cost to the Government.

3.2.5.4 Excavation for Appurtenances

Provide excavation for manholes, catch-basins, inlets, or similar structures of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Clean rock or loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Remove loose disintegrated rock and thin strata. Specify removal of unstable material. When concrete or masonry is to be placed in an excavated area, take special care not to disturb the bottom of the excavation. Do not excavate to the final grade level until just before the concrete or masonry is to be placed.

3.2.5.5 Jacking, Boring, and Tunneling

Unless otherwise indicated, provide excavation by open cut except that sections of a trench may be jacked, bored, or tunneled if, in the opinion of the Geotechnical Engineer, the pipe, cable, or duct can be safely and properly installed and backfill can be properly compacted in such sections.

3.2.6 Underground Utilities

The Contractor is responsible for movement of construction machinery and equipment over pipes and utilities during construction. Excavation made with power-driven equipment is not permitted within 2 feet of known Government-owned utility or subsurface construction. For work immediately adjacent to or for excavations exposing a utility or other buried obstruction, excavate by hand. Start hand excavation on each side of the

indicated obstruction and continue until the obstruction is uncovered or until clearance for the new grade is assured. Support uncovered lines or other existing work affected by the contract excavation until approval for backfill is granted by the Geotechnical Engineer. Report damage to utility lines or subsurface construction immediately to the Geotechnical Engineer.

3.2.7 Structural Excavation

Ensure that footing subgrades have been inspected and approved by the Geotechnical Engineer prior to concrete placement. Excavate to bottom of pile cap prior to placing or driving piles, unless authorized otherwise by the Geotechnical Engineer. Backfill and compact over excavations and changes in grade due to pile driving operations to 95 percent of ASTM D698 maximum density.

3.3 SELECTION OF BORROW MATERIAL

Select borrow material to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Obtain borrow material from the borrow areas within the limits of the project site, selected by the Contractor or from approved private sources. Unless otherwise provided in the contract, the Contractor is responsible for obtaining the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling from the owners. Borrow material from approved sources on Government-controlled land may be obtained without payment of royalties. Unless specifically provided, do not obtain borrow within the limits of the project site without prior written approval. Consider necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon related operations to the borrow excavation.

3.4 OPENING AND DRAINAGE OF EXCAVATION AND BORROW PITS

Notify the Geotechnical Engineer sufficiently in advance of the opening of any excavation or borrow pit or borrow areas to permit elevations and measurements of the undisturbed ground surface to be taken. Except as otherwise permitted, excavate borrow pits and other excavation areas providing adequate drainage. Transport overburden and other spoil material to designated spoil areas or otherwise dispose of as directed. Provide neatly trimmed and drained borrow pits after the excavation is completed. Ensure that excavation of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

3.5 SHORING

3.5.1 General Requirements

Submit a Shoring and Sheeting plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Finish shoring, including sheet piling, and install as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Remove shoring, bracing, and sheeting as excavations are backfilled, in a manner to prevent caving.

3.5.2 Geotechnical Engineer

Cooperate with the Owner's Professional Geotechnical Engineer to provide inspection of excavations and soil/groundwater conditions throughout construction. The Geotechnical Engineer is responsible for performing pre-construction and periodic site visits throughout construction to assess site conditions. The Geotechnical Engineer is responsible for updating the excavation, sheeting and dewatering plans as construction progresses to reflect changing conditions and submit an updated plan if necessary. Submit a monthly written report, informing the Contractor and Geotechnical Engineer of the status of the plan and an accounting of the Contractor's adherence to the plan addressing any present or potential problems.

3.6 GRADING AREAS

Where indicated, divide work into grading areas within which satisfactory excavated material will be placed in embankments, fills, and required backfills. Do not haul satisfactory material excavated in one grading area to another grading area except when so directed in writing. Place and grade stockpiles of satisfactory and unsatisfactory and wasted materials as specified. Keep stockpiles in a neat and well drained condition, giving due consideration to drainage at all times. Clear, grub, and seal by rubber-tired equipment, the ground surface at stockpile locations; separately stockpile excavated satisfactory and unsatisfactory materials. Protect stockpiles of satisfactory materials from contamination which may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, remove and replace such material with satisfactory material from approved sources.

3.7 FINAL GRADE OF SURFACES TO SUPPORT CONCRETE

Do not excavate to final grade until just before concrete is to be placed. For pile foundations, stop the excavation at an elevation of from 6 to 12 inches above the bottom of the footing before driving piles. After pile driving has been completed, complete the remainder of the excavation to the elevations shown. Only use excavation methods that will leave the foundation rock in a solid and unshattered condition. Roughen the level surfaces, and cut the sloped surfaces, as indicated, into rough steps or benches to provide a satisfactory bond. Protect shales from slaking and all surfaces from erosion resulting from ponding or water flow.

3.8 GROUND SURFACE PREPARATION

3.8.1 General Requirements

Remove and replace unsatisfactory material with satisfactory materials, as directed by the Geotechnical Engineer, in surfaces to receive fill or in excavated areas. Scarify the surface to a depth of 6 inches before the fill is started. Plow, step, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so that the fill material will bond with the existing material. When subgrades are less than the specified density, break up the ground surface to a minimum depth of 6 inches, pulverizing, and compacting to the specified density. When the subgrade is part fill and part excavation or natural ground, scarify the excavated or natural ground portion to a depth of 12 inches and compact it as specified for the adjacent fill.

3.9 UTILIZATION OF EXCAVATED MATERIALS

Use satisfactory material removed from excavations, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes. Dispose surplus satisfactory excavated material not required for fill and unsatisfactory excavated material as specified in paragraph DISPOSITION OF SURPLUS MATERIAL. Stockpile and use coarse rock from excavations for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. Do not dispose excavated material to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

3.10 BURIED TAPE AND DETECTION WIRE

3.10.1 Buried Warning and Identification Tape

Provide buried utility lines with utility identification tape. Bury tape 12 inches below finished grade; under pavements and slabs, bury tape 6 inches below top of subgrade.

3.10.2 Buried Detection Wire

Bury detection wire directly above non-metallic piping at a distance not to exceed 12 inches above the top of pipe. Extend the wire continuously and unbroken, from manhole to manhole. Terminate the ends of the wire inside the manholes at each end of the pipe, with a minimum of 3 feet of wire, coiled, remaining accessible in each manhole. Furnish insulated wire over its entire length. Install wires at manholes between the top of the corbel and the frame, and extend up through the chimney seal between the frame and the chimney seal. For force mains, terminate the wire in the valve pit at the pump station end of the pipe.

3.11 FILLING, BACKFILLING AND COMPACTION

Place fill and backfill beneath and adjacent to any and all type of structures, in successive horizontal layers of loose material not more than 8 inches in depth, or in loose layers not more than 5 inches in depth when using hand-operated compaction equipment. Compact to at least 90 percent of laboratory maximum density for cohesive materials or 95 percent of laboratory maximum density for cohesionless materials, except as otherwise specified. Perform compaction in such a manner as to prevent wedging action or eccentric loading upon or against the structure. Moisture condition fill and backfill material to a moisture content that will readily facilitate obtaining the specified compaction within range of +2 or -2 percent of optimum moisture content at the time of compaction.

Prepare ground surface on which backfill is to be placed and provide compaction requirements for backfill materials in conformance with the applicable portions of paragraphs GROUND SURFACE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.11.1 Trench Backfill

Backfill trenches to the grade shown. Do not backfill the trench until all specified tests are performed.

3.11.1.1 Replacement of Unyielding Material

Replace unyielding material removed from the bottom of the trench with select granular material or initial backfill material.

3.11.1.2 Replacement of Unstable Material

Replace unstable material removed from the bottom of the trench or excavation with select granular material placed in layers not exceeding 6 inches loose thickness.

3.11.1.3 Bedding and Initial Backfill

Provide bedding of the type and thickness shown in the drawings. Place initial backfill material and compact it with approved tampers to a height of at least one foot above the utility pipe or conduit. Bring up the backfill evenly on both sides of the pipe for the full length of the pipe. Take care to ensure thorough compaction of the fill under the haunches of the pipe. Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Compact backfill to top of pipe to 95 percent of ASTM D698 maximum density. Provide plastic piping with bedding to spring line of pipe. Provide materials as follows:

3.11.1.3.1 Class I

Angular, 0.25 to 1.5 inch, graded stone, including a number of fill materials that have regional significance such as coral, slag, cinders, crushed stone, and crushed shells.

3.11.1.3.2 Class II

Coarse sands and gravels with maximum particle size of 1.5 inch, including various graded sands and gravels containing small percentages of fines, generally granular and noncohesive, either wet or dry. Soil Types GW, GP, SW, and SP are included in this class as specified in ASTM D2487.

3.11.1.3.3 Sand

Clean, coarse-grained sand classified as SW/SP in accordance with GA DOT State Standards or SW/SP by ASTM D2487 for bedding and backfill as indicated.

3.11.1.3.4 Gravel and Crushed Stone

Clean, coarsely graded natural gravel, crushed stone or a combination thereof identified as GW/GP in accordance GA DOT State Standard or having a classification of GW/GP in accordance with ASTM D2487 for bedding and backfill as indicated. Do not exceed maximum particle size of 3 inches.

3.11.1.4 Final Backfill

Fill the remainder of the trench, except for special materials for roadways, railroads and airfields, with satisfactory material. Place backfill material and compact as follows:

3.11.1.4.1 Roadways

Place backfill up to the required elevation as specified. Do not permit water flooding or jetting methods of compaction.

3.11.1.4.2 Turfed or Seeded Areas and Miscellaneous Areas

Deposit backfill in layers of a maximum of 12 inches loose thickness, and compact it to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Allow water flooding or jetting methods of compaction for granular noncohesive backfill material. Do not allow water jetting to penetrate the initial backfill. Do not permit compaction by water flooding or jetting. Apply this requirement to all other areas not specifically designated above.

3.11.2 Backfill for Appurtenances

After the manhole, catchbasin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 7 days, place backfill in such a manner that the structure is not be damaged by the shock of falling earth. Deposit the backfill material, compact it as specified for final backfill, and bring up the backfill evenly on all sides of the structure to prevent eccentric loading and excessive stress.

3.12 SPECIAL REQUIREMENTS

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

3.12.1 Water Lines

Excavate trenches to a depth that provides a minimum cover of 3 feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe. For fire protection yard mains or piping, an additional 12 inch of cover is required.

3.12.2 Electrical Distribution System

Provide a minimum cover of 24 inches from the finished grade to direct burial cable and conduit or duct line, unless otherwise indicated.

3.12.3 Cleaning

Clean inside of the pipeline casing of dirt, weld splatters, and other foreign matter which would interfere with insertion of the piped utilities by attaching a pipe cleaning plug to the boring rig and passing it through the pipe.

3.12.3.1 End Seals

After installation of piped utilities in pipeline casing, provide watertight end seals at each end of pipeline casing between pipeline casing and piping utilities. Provide watertight end seals as indicated.

3.12.4 Rip-Rap Construction

Construct rip-rap on filter fabric in accordance with GA DOT State Standard, in the areas indicated. Trim and dress indicated areas to conform to cross sections, lines and grades shown within a tolerance of 0.1 foot.

3.12.4.1 Bedding Placement

Spread bedding material uniformly to a thickness of at least 3 inches on prepared subgrade as indicated. Compaction of bedding is not required. Finish bedding to present even surface free from mounds and windrows.

3.12.4.2 Stone Placement

Place rock for rip-rap on prepared bedding material to produce a well graded mass with the minimum practicable percentage of voids in conformance with lines and grades indicated. Distribute larger rock fragments, with dimensions extending the full depth of the rip-rap throughout the entire mass and eliminate "pockets" of small rock fragments. Rearrange individual pieces by mechanical equipment or by hand as necessary to obtain the distribution of fragment sizes specified above. For grouted rip-rap, hand-place surface rock with open joints to facilitate grouting and do not fill smaller spaces between surface rock with finer material. Provide at least one "weep hole" through grouted rip-rap for every 50 square feet of finished surface. Provide weep holes with columns of bedding material, 4 inches in diameter, extending up to the rip-rap surface without grout.

3.13 EMBANKMENTS

3.13.1 Earth Embankments

Construct earth embankments from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 3 inches. Place the material in successive horizontal layers of loose material not more than 8 inches in depth. Spread each layer uniformly on a soil surface that has been moistened or aerated as necessary, and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed. After spreading, plow, disk, or otherwise break up each layer; moisten or aerate as necessary; thoroughly mix; and compact to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials. Backfill and fill material must be within the range of -2 to +2 percent of optimum moisture to a moisture content that will readily facilitate obtaining the specified compaction.

Compaction requirements for the upper portion of earth embankments forming subgrade for pavements are identical with those requirements specified in paragraph SUBGRADE PREPARATION. Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

3.14 SUBGRADE PREPARATION

3.14.1 Proof Rolling

Finish proof rolling on an exposed subgrade free of surface water which would promote degradation of an otherwise acceptable subgrade. After

stripping, proof roll the existing subgrade with six passes of a dump truck loaded with 4 cubic yards of soil. Operate the truck in a systematic manner to ensure the number of passes over all areas, and at speeds between 2-1/2 to 3-1/2 mph. When proof rolling, provide one-half of the passes made with the roller in a direction perpendicular to the other passes. Notify the Geotechnical Engineer a minimum of 3 days prior to proof rolling. Perform proof rolling in the presence of the Geotechnical Engineer. Undercut rutting or pumping of material as directed by the Geotechnical Engineer and replace with select material.

3.14.2 Construction

Shape subgrade to line, grade, and cross section, and compact as specified. Include plowing, disking, and any moistening or aerating required to obtain specified compaction for this operation. Remove soft or otherwise unsatisfactory material and replace with satisfactory excavated material or other approved material as directed. Excavate rock encountered in the cut section to a depth of 6 inches below finished grade for the subgrade. Bring up low areas resulting from removal of unsatisfactory material or excavation of rock to required grade with satisfactory materials, and shape the entire subgrade to line, grade, and cross section and compact as specified. After rolling, the surface of the subgrade for roadways shall not show deviations greater than 1/2 inch when tested with a 12-foot straightedge applied both parallel and at right angles to the centerline of the area. Do not vary the elevation of the finish subgrade more than 0.05 foot from the established grade and cross section.

3.14.3 Compaction

Finish compaction by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Except for paved areas, compact each layer of the embankment to at least 95 percent of laboratory maximum density.

3.15 FINISHING

Finish the surface of excavations, embankments, and subgrades to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Provide the degree of finish for graded areas within 0.1 foot of the grades and elevations indicated except that the degree of finish for subgrades specified in paragraph SUBGRADE PREPARATION. Finish gutters and ditches in a manner that will result in effective drainage. Finish the surface of areas to be turfed to a smoothness suitable for the application of turfing materials. Repair graded, topsoiled, or backfilled areas prior to acceptance of the work, and re-established grades to the required elevations and slopes.

3.15.1 Subgrade and Embankments

During construction, keep embankments and excavations shaped and drained. Maintain ditches and drains along subgrade to drain effectively at all times. Do not disturb the finished subgrade by traffic or other operation. Protect and maintain the finished subgrade in a satisfactory condition until ballast, subbase, base, or pavement is placed. Do not permit the storage or stockpiling of materials on the finished subgrade. Do not lay subbase, base course, ballast, or pavement until the subgrade has been checked and

approved, and in no case place subbase, base, surfacing, pavement, or ballast on a muddy, spongy, or frozen subgrade.

3.15.2 Capillary Water Barrier

Place a capillary water barrier under concrete floor and area-way slabs grade directly on the subgrade and compact with a minimum of two passes of a hand-operated plate-type vibratory compactor.

3.15.3 Grading Around Structures

Construct areas within 5 feet outside of each building and structure line true-to-grade, shape to drain, and maintain free of trash and debris until final inspection has been completed and the work has been accepted.

3.16 PLACING TOPSOIL

On areas to receive topsoil, prepare the compacted subgrade soil to a 2 inches depth for bonding of topsoil with subsoil. Spread topsoil evenly to a thickness of 4 inch and grade to the elevations and slopes shown. Do not spread topsoil when frozen or excessively wet or dry. Obtain material required for topsoil in excess of that produced by excavation within the grading limits from areas indicated.

3.17 TESTING

Perform testing by a Corps validated commercial testing laboratory or the Contractor's validated testing facility. Submit qualifications of the Corps validated commercial testing laboratory or the Contractor's validated testing facilities. If the Contractor elects to establish testing facilities, do not permit work requiring testing until the Contractor's facilities have been inspected, Corps validated and approved by the Geotechnical Engineer.

a. Determine field in-place density in accordance with ASTM D1556/D1556M

b. Check the calibration curves furnished with the moisture gauges along with density calibration checks as described in ASTM D6938; check the calibration of both the density and moisture gauges at the beginning of a job on each different type of material encountered and at intervals as directed by the Geotechnical Engineer. ASTM D2937, use the Drive Cylinder Method only for soft, fine-grained, cohesive soils. When test results indicate, as determined by the Contracting Officer, that compaction is not as specified, remove the material, replace and recompact to meet specification requirements.

c. Perform tests on recompacted areas to determine conformance with specification requirements. Appoint a registered professional civil engineer to certify inspections and test results. These certifications shall state that the tests and observations were performed by or under the direct supervision of the engineer and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

3.17.1 Fill and Backfill Material Gradation

One test per 200 cubic yards stockpiled or in-place source material. Determine gradation of fill and backfill material in accordance with ASTM C136/C136M.

3.17.2 In-Place Densities

a. One test per 2000 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by other than hand-operated machines.

b. One test per 200 square feet, or fraction thereof, of each lift of fill or backfill areas compacted by hand-operated machines.

c. One test per 1000 linear feet, or fraction thereof, of each lift of embankment or backfill for roads.

3.17.3 Moisture Contents

In the stockpile, excavation, or borrow areas, perform a minimum of two tests per day per type of material or source of material being placed during stable weather conditions. During unstable weather, perform tests as dictated by local conditions and approved by the Geotechnical Engineer.

3.17.4 Optimum Moisture and Laboratory Maximum Density

Perform tests for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 500 cubic yards of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

3.17.5 Tolerance Tests for Subgrades

Perform continuous checks on the degree of finish specified in paragraph SUBGRADE PREPARATION during construction of the subgrades.

3.18 DISPOSITION OF SURPLUS MATERIAL

Surplus material and excavated unsatisfactory material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber shall be properly disposed of in accordance with all applicable laws and regulations.

-- End of Section --

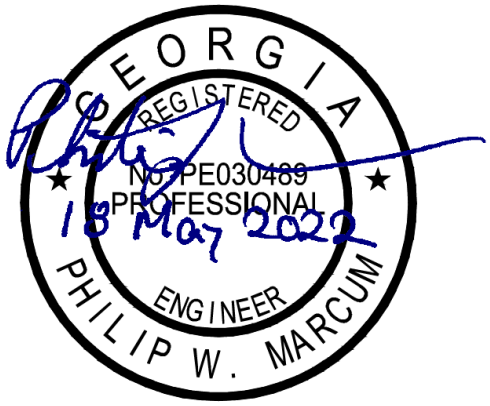
SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING

APPROVAL STATUS							
PREPARED BY:	PWM	**DATE**	17 May 2022	**CHECKED BY:**	DWD	**DATE**	17 May 2022
APPROVED BY:	PWM	**DATE**	17 May 2022				

REVISION STATUS						
REV	**ISSUED FOR**	**REVISED BY**	**CHECKED BY**	**APPROVAL**	**APPROVAL**	**DATE**
0	Permits					

Engineer's Seal



SECTION 33 11 00

WATER UTILITY DISTRIBUTION PIPING

PART 1 GENERAL

1.1 REFERENCES

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 SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B16.1	(2020) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C104/A21.4	(2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
AWWA C105/A21.5	(2018) Polyethylene Encasement for Ductile-Iron Pipe Systems
AWWA C110/A21.10	(2012) Ductile-Iron and Gray-Iron Fittings for Water
AWWA C111/A21.11	(2017) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
AWWA C115/A21.15	(2020) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
AWWA C151/A21.51	(2017) Ductile-Iron Pipe, Centrifugally Cast
AWWA C153/A21.53	(2019) Ductile-Iron Compact Fittings for Water Service
AWWA C200	(2012) Steel Water Pipe - 6 In. (150 mm) and Larger
AWWA C203	(2020) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
AWWA C205	(2018) Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. (100 mm) and Larger - Shop Applied
AWWA C206	(2017) Field Welding of Steel Water Pipe
AWWA C207	(2018) Standard for Steel Pipe Flanges for Waterworks Service, Sizes 4 in. through 144 in. (100 mm through 3600 mm)

AWWA C208	(2017) Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	(2019) Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections and Fitting for Steel Water Pipelines
AWWA C210	(2015) Standard for Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA C500	(2019) Metal-Seated Gate Valves for Water Supply Service
AWWA C504	(2015) Standard for Rubber-Seated Butterfly Valves
AWWA C508	(2017) Swing-Check Valves for Waterworks Service, 2 In. Through 48-In. (50-mm Through 1,200-mm) NPS
AWWA C509	(2015) Resilient-Seated Gate Valves for Water Supply Service
AWWA C512	(2015) Air-Release, Air/Vacuum, and Combination Air Valves for Water and Wastewater Service
AWWA C515	(2020) Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
AWWA C550	(2017) Protective Interior Coatings for Valves and Hydrants
AWWA C600	(2017) Installation of Ductile-Iron Mains and Their Appurtenances
AWWA C602	(2011) Cement-Mortar Lining of Water Pipelines in Place—4 In. (100 mm) and Larger
AWWA C604	(2011) Installation of Buried Steel Water Pipe—4 In. (100 mm) and Larger
AWWA C605	(2021) Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings
AWWA C606	(2015) Grooved and Shouldered Joints
AWWA C651	(2014) Standard for Disinfecting Water Mains
AWWA C655	(2009) Field Dechlorination
AWWA C800	(2021) Underground Service Line Valves and Fittings

AWWA C906	(2021) Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) through 65 In., (1,575 mm) for Water Distribution and Transmission
AWWA M9	(2008; Errata 2013) Manual: Concrete Pressure Pipe
AWWA M11	(2016) Steel Pipe: A Guide for Design and Installation
AWWA M23	(2020) Manual: PVC Pipe - Design and Installation - Third Edition
AWWA M41	(2009; 3rd Ed) Ductile-Iron Pipe and Fittings
AWWA M45	(2013; 3rd Ed) Fiberglass Pipe Design
AWWA M55	(2020; 2nd Ed) PE Pipe - Design and Installation

ASTM INTERNATIONAL (ASTM)

ASTM A536	(1984; R 2019; E 2019) Standard Specification for Ductile Iron Castings
ASTM D2683	(2020) Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing
ASTM D2774	(2021) Underground Installation of Thermoplastic Pressure Piping
ASTM D3035	(2015) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
ASTM F714	(2021a) Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter
ASTM F1674	(2011) Standard Test Method for Joint Restraint Products for Use with PVC Pipe
ASTM F1962	(2020) Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings
ASTM F2164	(2018) Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure
ASTM F2206	(2019) Standard Specification for Fabricated Fittings of Butt-Fused Polyethylene (PE)

ASTM F3190	(2021) Standard Practice for Heat Fusion Equipment (HFE) Operator Qualification on Polyethylene (PE) and Polymide (PA) Pipe and Fittings

FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

FCCCHR List	(continuously updated) List of Approved Backflow Prevention Assemblies

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 24	(2022) Standard for the Installation of Private Fire Service Mains and Their Appurtenances

NSF INTERNATIONAL (NSF)

NSF/ANSI 14	(2020) Plastics Piping System Components and Related Materials
NSF/ANSI 61	(2020) Drinking Water System Components - Health Effects

UNDERWRITERS LABORATORIES (UL)

UL 262	(2004; Reprint Oct 2011) Gate Valves for Fire-Protection Service
UL 312	(2010; Reprint Mar 2018) UL Standard for Safety Check Valves for Fire-Protection Service

1.2 DEFINITIONS

1.2.1 Water Transmission Mains

Water transmission mains include water piping having diameters greater than 14-inch, specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.2.2 Water Mains

Water mains include water piping having diameters 4 through 14-inch, specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.2.3 Water Service Lines

Water service lines include water piping from a water main to a building service at a point approximately 5 feet from building or the point indicated on the drawings, specific materials, methods of joining and any appurtenances deemed necessary for a satisfactory system.

1.2.4 Additional Definitions

For additional definitions refer to the definitions in the applicable referenced standard.

1.3 SUBMITTALS

Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Connections;

SD-03 Product Data

Pipe, Fittings, Joints and Couplings;

Ball And Socket Joint;

Valves;

Fusion Joining

SD-06 Test Reports

Post-Construction Fusion Report;

Leakage Test

Hydrostatic Test

SD-07 Certificates

Pipe, Fittings, Joints and Couplings

Shop-Applied Lining and Coating

Lining

Lining for Fittings

Lining for Ductile Iron Fittings

Valves

Fusion Technician Qualifications;

SD-08 Manufacturer's Instructions

Ductile-Iron Piping

Polyethylene (PE) Pipe

1.4 QUALITY CONTROL

1.4.1 Qualifications

1.4.1.1 Backflow Preventers

1.4.1.1.1 Backflow Preventer Certificate

Certificate of Full Approval from FCCCHR List, University of Southern California, attesting that the design, size and make of each backflow preventer has satisfactorily passed the complete sequence of performance testing and evaluation for the respective level of approval. Certificate of Provisional Approval will not be acceptable.

1.4.1.2 Fusion Technician Qualifications

Submit a certificate from the manufacturer of the fusible pipe that shows the fusion technician is fully qualified to install fusible pipe of the types and sizes being used. Qualification must be current as of the actual date of fusion performance on the project.

1.4.1.2.1 Fusion Technician Qualification on Polyethylene (PE) Pipe and Fittings

Provide certification for PE Pipe heat fusion in accordance with ASTM F3190.

1.5 DELIVERY, STORAGE, AND HANDLING

1.5.1 Delivery and Storage

Inspect materials delivered to site for required pipe markings and damage. Unload and store with minimum handling and in accordance with manufacturer's instructions to prevent cuts, scratches and other damage. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, valves, fire hydrants, and other accessories free of dirt and debris or other contaminates.

1.5.2 Handling

Handle pipe, fittings, valves, fire hydrants, and other accessories in accordance with applicable AWWA standard, manufacturer's instructions and in a manner to ensure delivery to the trench in sound undamaged condition. Avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged. Do not place other material, hooks, or pipe inside a pipe or fitting after the coating has been applied. Inspect the pipe for defects before installation. Carry, do not drag pipe to the trench. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe. Clean the interior of pipe and accessories of foreign matter before being lowered into the trench and keep them clean during laying operations by plugging. Replace defective material without additional expense to the Government. Store rubber gaskets, not immediately installed, under cover or out of direct sunlight.

Handle ductile iron pipe, fittings, and accessories in accordance with AWWA C600 and AWWA M41. Handle PVC and PVCO pipe, fittings, and accessories in accordance with AWWA C605. Handle PE pipe, fittings, and accessories in accordance with AWWA M55. Handle fiberglass pipe, fittings, and accessories in accordance with AWWA M45. Handle steel pipe, fittings and accessories in accordance with AWWA C604.

PART 2 PRODUCTS

2.1 MATERIALS

All materials are intended for potable water use unless otherwise indicated. Comply with NSF/ANSI 61 or NSF/ANSI 14 for all potable water pipe, fittings and other applicable materials. Provide pipe, fittings and other applicable materials bearing NSF/ANSI 61 or NSF/ANSI 14 markings for potable water service.

Provide all materials in accordance with AWWA C800 and as indicated herein. Provide valves and fittings with pressure ratings equivalent to the pressure ratings of the pipe.

2.1.1 Pipe, Fittings, Joints And Couplings

Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on and rubber-gasketed bell-and-spigot joints. Include information concerning gaskets with submittal for joints and couplings.

2.1.1.1 Ductile-Iron Piping

2.1.1.1.1 Pipe and Fittings

Pipe, except flanged pipe, AWWA C151/A21.51, Pressure Class 350. Flanged pipe, AWWA C115/A21.15. Fittings, AWWA C110/A21.10 or AWWA C153/A21.53; fittings with push-on joint ends are to meet the same requirements as fittings with mechanical-joint ends, except for the factory modified bell design. Provide fittings with pressure ratings equivalent to that of the pipe. Provide compatible pipe ends and fittings for the specified joints. Provide cement-mortar lining, AWWA C104/A21.4, twice the standard thickness on pipe and fittings.

2.1.1.1.2 Joints and Jointing Material

Provide push-on joints or mechanical joints for pipe and fittings unless otherwise indicated. Provide mechanical joints where indicated. Provide flanged joints where indicated. Provide mechanically coupled type joints using a sleeve-type mechanical coupling where indicated. Provide grooved or shouldered type joints where indicated. Provide insulating joints where indicated. Sleeve-type mechanical couplings in lieu of push-on joints are acceptable, subject to the limitations specified in the paragraph SLEEVE-TYPE MECHANICAL COUPLINGS. Utilize grooved or shouldered type joints in lieu of flanged joint or push-on joint, except where joint is buried.

a. Push-On Joints: Shape of pipe ends and fitting ends, gaskets, and lubricant for joint assembly as recommended in AWWA C111/A21.11.

b. Mechanical Joints: Dimensional and material requirements for pipe ends, glands, bolts and nuts, and gaskets as recommended in AWWA C111/A21.11.

c. Flanged Joints: Bolts, nuts, and gaskets for flanged connections as recommended in Appendix A of AWWA C115/A21.15. Provide AWWA C115/A21.15 ductile iron flanges and conform to ASME B16.1, Class 125.

2.1.1.2 Plastic Piping

2.1.1.2.1 Polyethylene (PE) Pipe

AWWA C906, ASTM F714, PE4710, minimum cell class PE 445574C, oxidative resistance classification CC3 with a minimum Pressure Class 200 (DR11) and ductile iron outside diameter (DIOD, unless otherwise noted.

2.1.1.2.1.1 Fittings For PE Pipe

Ductile iron fittings, AWWA C110/A21.10 or compact ductile iron fittings in accordance with AWWA C153/A21.53, with cement-mortar lining for ductile iron fittings, AWWA C104/A21.4, standard thickness. Fittings with push-on joint ends are to conform to the same requirements as fittings with mechanical-joint ends.

AWWA C906, PE4710, ASTM D3035 minimum cell class PE 445574C, oxidative resistance classification CC3 with minimum Pressure Class 250, molded ASTM D2683 meeting or exceeding the requirements in AWWA C906 for caps, reducers, couplings, elbows, and tees.

2.1.1.2.1.2 Joints and Jointing Materials

Mechanical Joint: AWWA C111/A21.11 DIOD Mechanical joint adapter and gaskets for mechanical joints for joint connections between pipe and metal fittings, valves, and other accessories.

2.1.2 Valves

Provide a protective interior coating in accordance with AWWA C550.

2.1.2.1 Gate Valves 3 Inch Size and Larger

AWWA C500, AWWA C509, AWWA C515, or UL 262 and:

a. AWWA C500: nonrising stem type with double-disc gate and mechanical-joint ends or push-on joint ends compatible for the adjoining pipe

b. AWWA C509 or AWWA C515: nonrising stem type with mechanical-joint ends or resilient-seated gate valves 3 to 12 inches in size

c. UL 262: inside-screw type with operating nut, double-disc or split-wedge type gate, designed for a hydraulic working pressure of 175 psi, and have mechanical-joint ends or push-on joint ends as appropriate for the pipe to which it is joined.

Match materials for UL 262 gate valves to the reference standards specified in AWWA C500. Gate valves open by counterclockwise rotation of the valve stem. Stuffing boxes have 0-ring stem seals, except for those valves for which gearing is specified, in which case use conventional packing in place of 0-ring seal. Stuffing boxes are bolted and constructed so as to permit easy removal of parts for repair. Use gate valves with special ends for connection to cement piping or sleeve-type mechanical coupling in lieu of

mechanical-joint ends and push-on joint ends. Provide valve ends and gaskets for connection to cement piping or to sleeve-type mechanical couplings that conform to the requirements specified respectively for the joint or coupling. Provide AWWA C500 gate valves with gearing and indicator. Where an indicator post are shown, provide an indicator post flange for AWWA C500, AWWA C509, or AWWA C515 gate valves conforming to the requirements of UL 262. Provide AWWA C500 gate valves with bypasses. Provide gate valves on service lines with threaded ends. Gate valves on service lines have ends compatible with joining to the pipe used; push-on joint ends or mechanical-joint ends for joining to ductile-iron pipe or push-on joint ends or mechanical-joint ends for joining to PVC water main pipe; with AWWA C111/A21.11 gaskets and pipe ends. Provide all valves from one manufacturer.

2.1.2.2 Check Valves

Provide a protective interior coating in accordance with AWWA C550. Swing-check type, AWWA C508 or UL 312 and:

a. AWWA C508: Iron or steel body and cover and flanged ends

b. UL 312: Cast iron or steel body and cover, flanged ends, and designed for a minimum working pressure of 150 psi.

Materials for UL 312 check valves are to match the reference standards specified in AWWA C508. Provide check valves with a clear port opening. Provide spring-loaded weight-loaded check valves where indicated. Class 125 flanges are to match ASME B16.1. Provide grooved or shouldered ends grooved or shouldered type joints, as specified in the paragraph DUCTILE-IRON PIPING in lieu of flanged ends. Provide all check valves from one manufacturer.

2.1.2.3 Rubber-Seated Butterfly Valves

Provide rubber-seated butterfly valves and wafer type valves that match the performance requirements of AWWA C504. Wafer type valves not meeting laying length requirements are acceptable if supplied and installed with a spacer, providing the specified laying length. Meet all tests required by AWWA C504. Flanged-end valves are required in a pit. Provide a union or sleeve-type coupling in the pit to permit removal. Direct-bury mechanical-end valves 3 through 10 inches in diameter. Provide a valve box, means for manual operation, and an adjacent pipe joint to facilitate valve removal. Provide valve operators that restrict closing to a rate requiring approximately 60 seconds, from fully open to fully closed.

2.1.2.4 Pressure Reducing Valves – not used

2.1.2.5 Air Release, Air/Vacuum, and Combination Air Valves

Provide AWWA C512 air release, air vacuum and combination air valves that release air and prevent the formation of a vacuum. Provide valves with an iron body, lead-free bronze trim and stainless steel float that automatically releases air when the lines are being filled with water and admits air into the line when water is being withdrawn in excess of the inflow.

2.2 ACCESSORIES

2.2.1 Pipe Restraint

2.2.1.1 Joint Restraint

Provide restrained joints in accordance with NFPA 24, Chapter 10 and in accordance with ASTM F1674.

Provide restraint devices with gripper wedges incorporated into a follower gland and specifically designed for the pipe material and meeting the requirements of AWWA C110/A21.10.

2.2.2 Tracer Wire for Nonmetallic Piping

Provide a continuous bare copper or aluminum wire not less than 0.10 inch in diameter in sufficient length over each separate run of nonmetallic pipe.

PART 3 EXECUTION

3.1 PREPARATION

3.1.1 Earthwork

Perform earthwork operations in accordance with Section 31 00 00 EARTHWORK.

3.2 INSTALLATION

Install all materials in accordance with the applicable reference standard, manufacturers instructions and as indicated herein.

3.2.1 Piping

3.2.1.1 General Requirements

Install pipe, fittings, joints and couplings in accordance with the applicable referenced standard, the manufacturer's instructions and as specified herein.

3.2.1.1.1 Termination of Water Lines

Terminate the work covered by this section at a point approximately 5 feet from the building, unless otherwise indicated.

Do not lay water lines in the same trench with gas lines, fuel lines, electric wiring, or any other utility. Do not install copper tubing in the same trench with ferrous piping materials. Where nonferrous metallic pipe (i.e., copper tubing) crosses any ferrous piping, provide a minimum vertical separation of 12 inches between pipes.

3.2.1.1.2 Pipe Laying and Jointing

Remove fins and burrs from pipe and fittings. Before placing in position, clean pipe, fittings, valves, and accessories, and maintain in a clean condition. Provide proper facilities for lowering sections of pipe into trenches. Under no circumstances is it permissible to drop or dump pipe, fittings, valves, or other water line material into trenches. Cut pipe

cleanly, squarely, and accurately to the length established at the site and work into place without springing or forcing. Replace a pipe or fitting that does not allow sufficient space for installation of jointing material. Blocking or wedging between bells and spigots is not permitted. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying. Grade the pipeline in straight lines; avoid the formation of dips and low points. Support pipe at the design elevation and grade. Secure firm, uniform support. Wood support blocking is not permitted. Lay pipe so that the full length of each section of pipe and each fitting rests solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings. Provide anchors and supports for fastening work into place. Make provision for expansion and contraction of pipelines. Keep trenches free of water until joints have been assembled. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads. Do not lay pipe when conditions of trench or weather prevent installation. Provide a minimum of 2 1/2 feet depth of cover over top of pipe.

3.2.1.1.3 Tracer Wire

Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such manner that it will not be displaced during construction operations.

3.2.1.1.4 Water Piping Parallel With Sewer Piping

Where the location of the water line is not clearly defined by dimensions on the drawings, do not lay water line closer than 10 feet, horizontally, from any sewer line.

a. Normal Conditions: Lay water piping at least 10 feet horizontally from sewer or sewer manhole whenever possible. Measure the distance from outside edge to outside edge of pipe or outside edge of manhole. When local conditions prevent horizontal separation install water piping in a separate trench with the bottom of the water piping at least 18 inches above the top of the sewer piping.

b. Unusual Conditions: When local conditions prevent vertical separation, construct sewer piping of AWWA compliant ductile iron water piping and perform hydrostatic sewer test, without leakage, prior to backfilling. When local conditions prevent vertical separation, test the sewer manhole in place to ensure watertight construction.

3.2.1.1.5 Water Piping Crossing Sewer Piping

Provide at least 18 inches above the top (crown) of the sewer piping and the bottom (invert) of the water piping whenever possible. Measure the distance edge-to-edge. Where water lines cross under gravity sewer lines, construct sewer line of AWWA compliant ductile iron water piping with rubber-gasketed joints and no joint located within 10 feet, horizontally, of the crossing. Lay water lines which cross sewer force mains and inverted siphons at least 2 feet above these sewer lines; when joints in the sewer line are closer than 3 feet horizontally from the water line relay the sewer line to ensure no joint closer than 3 feet.

a. Normal Conditions: Provide a separation of at least 18 inches between the bottom of the water piping and the top of the sewer piping in cases where water piping crosses above sewer piping.

b. Unusual Conditions: When local conditions prevent a vertical separation described above, construct sewer piping passing over or under water piping of AWWA compliant ductile iron water piping and perform hydrostatic sewer test, without leakage, prior to backfilling. Construct sewer crossing with a minimum 20 feet length of the AWWA compliant ductile iron water piping, centered at the point of the crossing so that joints are equidistant and as far as possible from the water piping. Protect water piping passing under sewer piping by providing a vertical separation of at least 18 inches between the bottom of the sewer piping and the top of the water piping; adequate structural support for the sewer piping to prevent excessive deflection of the joints and the settling on or damage to the water piping.

3.2.1.1.6 Penetrations

Provide ductile-iron or Schedule 40 steel wall sleeves for pipe passing through walls of valve pits and structures. Fill annular space between walls and sleeves with rich cement mortar. Fill annular space between pipe and sleeves with mastic.

3.2.1.1.7 Flanged Pipe

Only install flanged pipe aboveground or with the flanges in valve pits.

3.2.1.2 Ductile-Iron Piping

Unless otherwise specified, install pipe and fittings in accordance with the paragraph GENERAL REQUIREMENTS and with the requirements of AWWA C600 for pipe installation, joint assembly, valve-and-fitting installation, and thrust restraint.

a. Jointing: Make push-on joints with the gaskets and lubricant specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 and AWWA M41 for joint assembly. Make mechanical joints with the gaskets, glands, bolts, and nuts specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 and AWWA M41 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11. Make flanged joints with the gaskets, bolts, and nuts specified for this type joint. Make flanged joints up tight; avoid undue strain on flanges, fittings, valves, and other equipment and accessories. Align bolt holes for each flanged joint. Use full size bolts for the bolt holes; use of undersized bolts will not be permitted. Do not allow adjoining flange faces to be out of parallel to such degree that the flanged joint cannot be made watertight without overstraining the flange. When flanged pipe or fitting has dimensions that do not allow the making of a flanged joint as specified, replace it. Use set screw flanges to make flanged joints where conditions prevent the use of full-length flanged pipe and assemble in accordance with the recommendations of the set screw flange manufacturer. During installation of set screw gasket provide for confinement and compression of gasket when joint to adjoining flange is made. Assemble joints made with sleeve-type mechanical couplings in accordance with the recommendations of the coupling manufacturer. Make grooved and shouldered type joints with the couplings previously specified for this type joint connecting pipe with the grooved or shouldered ends specified for this type joint;

assemble in accordance with the recommendations of the coupling manufacturer. Groove pipe in the field only with groove cutting equipment designed especially for the purpose and produced by a manufacturer of grooved joint couplings; secure approval for field-cut grooves before assembling the joint. Make insulating joints with the gaskets, sleeves, washers, bolts, and nuts previously specified for this type joint. Assemble insulating joints as specified for flanged joints, except that bolts with insulating sleeves are to be full size for the bolt holes. Ensure that there is no metal-to-metal contact between dissimilar metals after the joint has been assembled.

b. Allowable Deflection: Follow AWWA C600 and AWWA M41 for the maximum allowable deflection. If the alignment requires deflection in excess of the above limitations, provide special bends or a sufficient number of shorter lengths of pipe to achieve angular deflections within the limit set forth.

c. Exterior Protection: Completely encase buried ductile iron pipelines with polyethylene film, in accordance with AWWA C105/A21.5.

3.2.1.3 Polyethylene (PE) Piping

Install PE pipes in accordance with AWWA M55, ASTM D2774 and the manufacturer's installation instructions.

3.2.1.5 Polyethylene Pipe

Install butt fused PE Pipe in accordance with AWWA M55 and ASTM F1962.

3.2.1.5.1 Post-Construction Fusion Report

Include the following data for each fusible connection in the report:

a. Pipe Size and Thickness

b. Machine Size

c. Fusion Technician Identification

d. Job Identification

e. Fusion Joint Number

f. Fusion, Heating, and Drag Pressure Settings

g. Heat Plate Temperature

h. Time Stamp

i. Heating and Cool Down Time of Fusion

j. Ambient Temperature

3.2.2 Disinfection

Disinfection of systems supplying non-potable water is not required.

Prior to disinfection, provide disinfection procedures, proposed neutralization and disposal methods of waste water from disinfection as part of the disinfection submittal. Disinfect new water piping and existing water piping affected by Contractor's operations in accordance with AWWA C651. Disinfect new water piping using the AWWA C651 continuous-feed method of chlorination. Ensure a free chlorine residual of not less than 10 parts per million after 24 hour holding period and prior to performing bacteriological tests.

3.2.3 Flushing

Perform bacteriological tests prior to flushing. Flush solution from the systems with domestic water until maximum residual chlorine content is within the range of 0.2 to 0.5 parts per million, the residual chlorine content of the distribution system, or acceptable for domestic use. Use AWWA C655 neutralizing chemicals.

3.2.4 Pipe Restraint

3.2.4.1 Restrained Joints

Install restrained joints in accordance with the manufacturer's instructions NFPA 24 where indicated. For metal harness use tie rods and clamps as shown in NFPA 24. Provide structural welded, skip welded, clamp type harness, bell bolt harness, snap ring harness for pipe anchorage. Provide metal harness fabricated by the pipe manufacturer and furnished with the pipe.

3.2.5 Valves

3.2.5.1 Gate Valves

Install gate valves, AWWA C500 and UL 262, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C500. Install gate valves, AWWA C509 or AWWA C515, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C509 or AWWA C515. Install gate valves on PVC and PVCO water mains in accordance with the recommendations for appurtenance installation in AWWA M23, Chapter 7, "Installation." Make and assemble joints to gate valves as specified for making and assembling the same type joints between pipe and fittings.

3.2.5.2 Check Valves

Install check valves in accordance with the applicable requirements of AWWA C600 for valve-and-fitting installation, except as otherwise indicated. Make and assemble joints to check valves as specified for making and assembling the same type joints between pipe and fittings.

3.2.5.3 Air Release, Air/Vacuum, and Combination Air Valves

Install pressure vacuum assemblies of type, size, and capacity indicated. Include valves and test cocks. Install according to the requirements of plumbing and health department and authorities having jurisdiction. Do not install pressure vacuum breaker assemblies in vault or other space subject to flooding.

3.3 FIELD QUALITY CONTROL

3.3.1 Tests

Notify the Contracting Officer a minimum of five days in advance of hydrostatic testing. Coordinate the proposed method for disposal of waste water from hydrostatic testing. Perform field tests, and provide labor, equipment, and incidentals required for testing, except that water needed for field tests will be furnished as set forth in paragraph AVAILABILITY AND USE OF UTILITY SERVICES in Section 01 50 00 TEMPORARY CONSTRUCTION FACILITIES AND CONTROLS. Provide documentation that all items of work have been constructed in accordance with the Contract documents.

3.3.1.1 Hydrostatic Test

Test the water system in accordance with the applicable AWWA standard specified below. Where water mains provide fire service, test in accordance with the special testing requirements given in the paragraph SPECIAL TESTING REQUIREMENTS FOR FIRE SERVICE. Test ductile-iron water mains in accordance with the requirements of AWWA C600 for hydrostatic testing. The amount of leakage on ductile-iron pipelines with mechanical-joints or push-on joints is not to exceed the amounts given in AWWA C600; no leakage will be allowed at joints made by any other methods. Test PVC and PVCO plastic water systems made with PVC pipe in accordance with the requirements of AWWA C605 for pressure and leakage tests. The amount of leakage on pipelines made of PVC water main pipe is not to exceed the amounts given in AWWA C605, except that at joints made with sleeve-type mechanical couplings, no leakage will be allowed. Test PE pipe in accordance with the requirements of AWWA M55 for hydrostatic testing. Test concrete water mains in accordance with the recommendations in AWWA M9, "Hydrostatic Testing and Disinfection of Mains." The amount of leakage on concrete pipelines is not to exceed 20 gallons per 24 hours per inch of pipe diameter per mile of pipeline. Test steel water mains in accordance with applicable requirements of AWWA C600 for hydrostatic testing. The amount of leakage on steel pipelines with rubber-gasketed bell-and-spigot joints is not to exceed 20 gallons per 24 hours per inch of pipe diameter per mile of pipeline; no leakage will be allowed at joints made by any other method. To stop leakage, repair welded joints only by welding. Test water service lines in accordance with requirements of AWWA C600 for hydrostatic testing. No leakage will be allowed at copper pipe joints, copper tubing joints (soldered, compression type, brazed), plastic service pipe joints, flanged joints. Do not backfill utility trench or begin testing on any section of a pipeline where concrete thrust blocks have been provided until at least 7 days after placing of the concrete.

3.3.1.2 Hydrostatic Sewer Test

The hydrostatic pressure sewer test will be performed in accordance with the applicable AWWA standard for the piping material or AWWA C600.

3.3.1.3 Leakage Test

For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

For PE pipe perform leak testing in accordance with AWWA M55, ASTM F2164.

3.3.1.4 Tracer Wire Continuity Test

Test tracer wire for continuity after service connections have been completed and prior to final pavement or restoration. Verify that tracer wire is locatable with electronic utility locating equipment. Repair breaks or separations and re-test for continuity.

3.4 SYSTEM STARTUP

Water mains and appurtenances must be completely installed, disinfected, flushed, and satisfactory bacteriological sample results received prior to permanent connections being made to the active distribution system. Obtain approval by the Contracting Officer prior to the new water piping being placed into service.

3.5 CLEANUP

Upon completion of the installation of water lines and appurtenances, remove all debris and surplus materials resulting from the work.

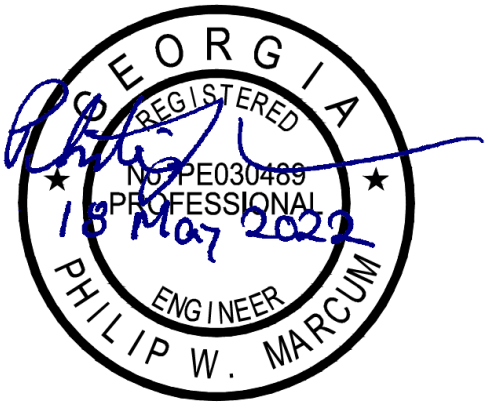
-- End of Section --

SECTION 31 05 20.10
HDPE GEOMEMBRANE

APPROVAL STATUS							
PREPARED BY:	PWM	**DATE**	17 May 2022	**CHECKED BY:**	DWD	**DATE**	17 May 2022
APPROVED BY:	PWM	**DATE**	17 May 2022				

REVISION STATUS						
REV	**ISSUED FOR**	**REVISED BY**	**CHECKED BY**	**APPROVAL**	**APPROVAL**	**DATE**
0	Permits					

Engineer's Seal



SECTION 31 05 20.10

HDPE GEOMEMBRANE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section includes the geomembrane liner fabricated from the following:

1. 60-mil high-density polyethylene (HDPE) double sided textured membrane.

B. Related Requirements:

1. Section 01 45 36 “Interface Friction Conformance Testing.”
2. Section 01 45 47 “Geoelectric Survey for Detection of Geomembrane Leaks.”
3. Section 02 21 00 “Surveying.”
4. Section 31 05 13.30 “Protective Cover Materials.”
5. Section 31 05 19.13 “Geotextiles.”
6. Section 31 05 19.23 “Geosynthetic Clay Liner.”
7. Section 31 05 19.26 “Geocomposites.”
8. Section 31 20 00 “Earth Moving.”
9. Section 31 23 33 “Trenching and Backfilling.”

1.2 REFERENCES

A. Construction Quality Assurance (CQA) Plan

B. ASTM International:

1. ASTM D792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
2. ASTM D1004, Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting.
3. ASTM D1505, Standard Test Method for Density of Plastics by the Density-Gradient Technique.
4. ASTM D1603, Standard Test Method for Carbon Black Content in Olefin Plastics.
5. ASTM D3895, Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry.
6. ASTM D4218, Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
7. ASTM D4833, Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.
8. ASTM D4873, Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.
9. ASTM D5397, Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test (Appendix - Procedure to Perform a Single Point Notched Constant Tensile Load (SP-NCTL) Test).

10. ASTM D5596, Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics.
11. ASTM D5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
12. ASTM D5721, Standard Practice for Air-Oven Aging of Polyolefin Geomembranes.
13. ASTM D5820, Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes.
14. ASTM D5885, Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry.
15. ASTM D5994, Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
16. ASTM D6365, Standard Practice for the Nondestructive Testing of Geomembrane Seams using the Spark Test.
17. ASTM D6392, Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.
18. ASTM D6693, Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes.
19. ASTM D7238, Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus.
20. ASTM D7466, Standard Test Method for Measuring the Asperity Height of Textured Geomembrane.

C. Geosynthetic Research Institute (GRI):
1. GRI GM6 – Pressurized Air Channel Test for Dual Seamed Geomembranes.
2. GRI-GM13, “Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes.”
3. GRI-GM19, “Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.”

1.3 SUBMITTALS

A. Submit the following to the Engineer with the Contractor’s bid:

1. A material properties sheet for each geomembrane product, including at a minimum all properties, test methods, and test values as required by this specification.
2. Example Material Warranty and Workmanship Warranty as required by this specification.
3. The “Geosynthetic Contractor Qualifications Questionnaire” included in the contract bid documents.

B. Submit the following to the Engineer, for review and approval, no later than 15 calendar days prior to shipment of geomembrane to the site:

1. Manufacturer’s quality control program manual, or descriptive documentation.
2. The manufacturers’ quality control certifications (including results of source quality control testing of the products as required by this specification) to verify that the materials supplied for the project are in compliance with the product specifications in this section. The certifications shall be signed by a responsible party employed by the manufacturer, such as the geomembrane Quality Control Manager, Production Manager, or Technical Services Manager. Certifications shall include lot and roll numbers, and corresponding shipping information.

3. A written certificate from the geomembrane manufacturer stating that the resin and geomembrane materials supplied are in compliance with this specification.
4. A written certificate from the geomembrane manufacturer stating that no more than 2% by weight of factory regrind was used to manufacture the geomembrane. Factory regrind shall have resin documentation.
5. Documentation of installers' qualifications, as required by this specification.
    a. Submit a list of at least ten completed facilities. For each installation, provide: name and type of facility; its location; the date of installation; name and telephone number of the facility's owner, design Engineer, manufacturer, and fabricator, if applicable; name and telephone number of contact at the facility; thickness of geomembrane and surface area of the installed geomembrane; and type of seaming, patching, and tacking equipment.
    b. Submit resumes or qualifications of the Installation Supervisor, Master Seamer and all technicians to be assigned to this project.
6. Manufacturer's instruction manual for geomembrane on-site handling and installation, including but not limited to procedures for storage, transport, placement, seaming, and testing.
7. Submit copies of shop drawings. Shop drawings shall show a proposed installation panel layout identifying seams and details (including sealing of penetrations).

C. On a continuous basis throughout construction, submit the following to the Engineer, for review and approval, with final documents provided no later than 14 calendar days following completion of geosynthetics installation:

1. Geosynthetics Quality Control Forms
    a. Daily Field Reports
    b. Field Inventory Control, Storage, Inspection, and Cross-Reference Roll Numbers
    c. Subgrade Certification
    d. Geomembrane Trial Seam Log
    e. Geomembrane Deployment Report
    f. Geomembrane Seam Log
    g. Geomembrane Seam Data Acquisition Welding Report
    h. Geomembrane Defect Log
    i. Geomembrane Repair Testing Log
    j. Geomembrane Laboratory Destructive Test Results
2. Record drawing for each geomembrane layer showing panel corners, transitions in panel geometry, repair locations, destructive test locations, anchor trench breaklines, and other significant features.
3. Provide a Letter of Acceptance indicating that the installation conforms to the requirements of the Manufacturer.
4. Manufacturer's material warranty as required by this specification.
5. Geomembrane installation guarantee as required by this specification.

1.4 QUALIFICATIONS

A. Installer's Qualifications:

1. The Geomembrane Installer shall be the manufacturer, or an approved contractor qualified to install the manufacturer's geomembrane, and have current AIC status issued by the International Association of Geosynthetic Installers (IAGI).
2. The Geomembrane Installer shall have installed at least 10 million square feet of the specified types of geomembrane during the last five years.
3. Installation shall be performed under the constant direction of a single Field Installation Supervisor who shall remain on site and be in responsible charge, throughout the geomembrane installation, for geomembrane layout, seaming, patching, testing, repairs, and all other activities by the Geomembrane Installer. This Field Installation Supervisor shall have installed or supervised the installation and seaming of a minimum of 5 million square feet of geomembrane of the types specified.
4. The Geomembrane Installer shall designate a Master Seamer. The Master Seamer shall be present during all seaming operations and shall have a minimum of 3 million square feet of field seaming experience and hold an IAGI Certified Welding Technician (CWT) welding certification in both extrusion welding and fusion welding.
5. All seaming, patching, other welding operations, and designated field testing shall be performed by qualified technicians employed and trained by the Geomembrane Installer. Other specified quality control inspection and testing shall be performed by the CQA Engineer and laboratory.
6. Geosynthetic Contractor Equipment and Personnel:

    a. Quality Control Foreman (QCF)

        1) The Geosynthetics Installer shall provide an individual whose title is “Quality Control Foreman” (QCF) who shall be experienced in all phases of quality control testing and procedures.
        2) The QCF will be dedicated to performing or directing the Geosynthetics Installer’s quality control activities, (i.e. air pressure, vacuum box and spark non-destructive testing and field destructive testing).
        3) The QCF and the Superintendent may be the same person if approved by the Engineer.

1.5 QUALITY CONTROL

A. The Manufacturer shall sample and test the HDPE geomembrane material at a minimum frequency as required by Table 310520.10A.

B. Interface Friction Testing Requirements

1. Refer to Specification Section 014536 “Interface Friction Conformance Testing” for interface friction testing requirements.

C. If the Manufacturer’s quality control test results do not conform to the requirements of this specification, retesting to determine conformance or rejection shall be done as set forth in the manufacturer’s quality manual at no additional cost to the CQA Engineer or Owner.

D. The Contractor shall perform Quality Control tests in accordance with Table 310520.10B of this section.

E. The Geomembrane Installer shall follow the procedures and requirements described in this section, including performing and documenting test seams, nondestructive and destructive seam tests, and repairs.

F. If any conformance test result does not conform to the requirements of the specifications, the roll from which the sample was obtained will be rejected. The Contractor shall replace any rejected roll at no cost to the Owner.

G. Electrical Leak Location/Liner Integrity Survey

1. The contractor shall perform (or subcontract) electrical leak location survey of the secondary geomembrane using methods defined in Specification Section 014547, Geoelectric Survey for Detection of Geomembrane Leaks.
2. Electrical leak location survey is not planned to be conducted on the primary geomembrane. The Owner may require an electrical leak location survey of the primary geomembrane if field conditions indicate leakage after installation. Therefore, measures prescribed in Specification Section 014547 shall be employed during primary geomembrane installation that allow for electrical leak location survey.
   Such measures include and are not limited to installing test wire between the primary and secondary geomembrane and not covering the anchor trench with protective cover materials.
3. Electrical leak location testing will be conducted on exposed geomembrane prior to installing overlying geosynthetics. Therefore, the Contractor and Geosynthetic Installer shall allow sufficient time in their schedule to accommodate testing and sufficient time for repair and retesting as needed prior to placing overlying geosynthetics.
4. The Geosynthetic Installer shall repair any defects identified in accordance with this Specification.
5. The Contractor/Geosynthetic Installer shall notify the CQA Engineer and Owner to provide a two week notice before performing the electrical leak location survey.

1.6 QUALITY ASSURANCE

A. Conformance Testing will be performed in accordance with the CQA Plan and coordinated by the CQA Engineer.

1. Conformance testing shall be performed on material specifically manufactured for this project.
2. Samples shall be taken across the entire width of the roll and shall not include the first three feet. Unless otherwise specified, samples shall be three feet long by the roll width. The machine direction shall be marked on the samples.
3. Required test methods and test frequencies are presented in the CQA Plan.

B. If any conformance test result does not conform to the requirements of this specification, retesting to determine conformance or rejection rolls other than the roll from which the sample was obtained shall be done as set forth in the manufacturer’s quality manual at no additional cost to the CQA Engineer or Owner.

1.7 WARRANTIES

A. The Contractor shall furnish the Owner a warranty from the Geomembrane Manufacturer for the materials used. The warranty shall be for defects or failures related to manufacture. Determination of the cause of defect or failure shall be by a third-party, not by the Geomembrane Manufacturer. The warranty period shall be five years from the date of final material delivery to site. Since five years is far less than the expected service life of the material, the warranty shall not be on a pro-rata basis.

B. The Contractor shall furnish the Owner a warranty from the Geomembrane Installer that warrants their workmanship to be free of defects. Determination of the cause of defect or failure shall be by a third-party, not by the Geomembrane Installer. The warranty period shall be five years from the date of completion of installation. Since five years is far less than the expected service life of the installed product, the warranty shall not be on a pro-rata basis. The guarantee shall include the services of qualified service technicians and all material required for the repairs at no expense to the Owner.

1.8 GEOMEMBRANE PRE-DEPLOYMENT MEETING

A. Geomembrane Pre-Deployment Meeting shall be held at the site prior to installation of the geomembrane. At a minimum, the meeting shall be attended by the Geomembrane Installer, Owner, CQA Engineer, Engineer, and Contractor.

B. Topics for this meeting shall include, but not be limited to, the following:

1. Responsibilities of each party.
2. Lines of authority and communication.
3. Methods for documenting and reporting, and for distributing documents and reports.
4. Processes for generating, distributing, and evaluating data acquisition reports.
5. Procedures for collecting and packaging archive samples.
6. Review of time schedule for all installation and testing.
7. Review of panel layout and numbering systems for panels, seams, and repairs.
8. Temperature and weather limitations, and installation procedures for adverse weather conditions.
9. Deployment techniques, including plans for controlling expansion, contraction and wrinkling of the geomembrane, access points, acceptable equipment and protection of geosynthetics.
10. Preparation of the geomembrane record survey drawing.

1.9 The meeting shall be documented by a person designated at the beginning of the meeting, and minutes shall be transmitted to all parties.

1.10 DELIVERY, STORAGE AND HANDLING

A. Each roll of geomembrane delivered to the Site shall be labeled by the manufacturer. The label shall be firmly affixed and shall clearly state the manufacturer's name, product identification, lot number, material thickness, roll number, roll dimensions, and roll weight.

B. Procedures for storage and handling of geomembrane shall conform to ASTM D4873 and the manufacturer instructions, including the following:

1. Geomembrane shall be protected from mud, dirt, dust, puncture, cutting or any other damaging or deleterious conditions.
2. Rolls shall be stored away from high traffic areas, protected from theft and vandalism.
3. Continuously and uniformly support rolls on a prepared level surface in accordance with the manufacturer's recommendations (not on wooden pallets) away from standing water. Rolls shall not be stacked more than two rolls high without prior approval by the Engineer.

C. Geomembrane shall be observed by the CQA personnel upon delivery of the product to the Site, and during installation and field seaming. Provide all labor and equipment required to assist CQA personnel in the observation of the product.

D. CQA personnel shall generate an inventory of geomembrane rolls received on-site from the manufacturer/distributor. The inventory shall include all the information appearing on the label of each roll, and all observed damage shall be noted.

PART 2 - PRODUCTS

2.1 HDPE GEOMEMBRANE

A. HDPE Sheet: Formulated from virgin PE, compounded for use in hydraulic structures, and formed into uniform sheets with material properties complying with this specification.

B. The geomembrane shall consist of new, first quality products designed and manufactured specifically for this type of project, which shall have been satisfactorily demonstrated by prior testing to be suitable and durable for such purposes.

C. Geomembrane shall contain no plasticizers, fillers, chemical additives, or extenders. Sprayed-on texturing of textured polyethylene geomembrane will not be accepted.

D. Geomembrane shall be supplied as continuous sheets with no factory seams in rolls. The roll lengths and widths shall be maximized to provide the largest manageable sheets for the fewest field seams.

E. Geomembrane material shall be produced free of holes, blisters, or contaminants, and leak-free as verified by spark testing using ASTM D6365.

F. Geomembrane shall have a protective film (tape) along its edges. The protective tape shall be approximately 6 inches (150 mm) wide and be applied at the factory. The tape shall be applied on roll edges alternating from the top of the roll on one side, to the bottom of the roll on the opposite side such that taped top/bottom edges match up during installation. Tape shall be electrostatically bonded to the roll. If adhesive is used, the manufacturer shall demonstrate that residual adhesive will not remain on the roll after tape removal.

G. Physical, Mechanical and Chemical Property Requirements

1. Textured HDPE geomembrane sheet shall meet or exceed the values specified in GRI-GM13, as summarized in Table 310520.10A at the end of this specification.

2.2 EQUIPMENT

A. Welding Equipment:

1. Fusion Welding Machine Requirements

   a. Fusion welding machines shall be a self-propelled and equipped with an electronic controller which displays the temperature, speed, and welding pressure.
   b. Fusion welding machines must accommodate on board monitoring and recording (data acquisition) of these three welding parameters throughout the welding process.
   c. Fusion welding machines shall be equipped with voltage display to allow for continuous monitoring of input voltage under load.

2. Fusion Welding Parameters and Tolerances

   a. Wedge temperature must be adjustable to the pre-determined target temperature and must maintain a tolerance of ±40° F during the welding process. If tolerance is exceeded a visual and/or audible alarm should immediately alert operator.
   b. The drive system must be designed in such a way that the set welding speed remains constant within ± 0.5 ft/min. irrespective of the load. If tolerance is exceeded a visual and/or audible alarm should immediately alert operator.
   c. Welding pressure must be adjustable to the pre-determined target pressure and monitored to maintain a consistency of ± 50 lb during the welding process. If tolerance is exceeded a visual and/or audible alarm should immediately alert operator.
   d. The Geosynthetic Installer shall establish the pre-determined target temperature and welding pressure based on their experience with welding similar products under similar installation conditions.

3. Welding Data Acquisition

   a. Welding machines shall be equipped with an on-board data acquisition system to demonstrate that the pre-determined test weld settings were consistent throughout the entire welding process.
   b. The recorded welding data shall be continuously saved regardless of the preset recording distance interval.
   c. The measured data must be stored in a way that it can be assigned and later produced for individual seams and specific weld lengths. Measured data shall be transmitted to the CQA Engineer daily in the Geomembrane Seam Data Acquisition Welding Report per Part 1.3.C.

4. Extrusion welding equipment shall be provided with thermocouples and temperature readout devices which continuously monitor the temperature of the extrudate. Equipment shall be maintained in adequate number to avoid delaying work and shall be supplied by a power source capable of providing constant voltage under a combined-line load. Use a rub sheet, sandbags, or other method approved by the CQA Engineer to separate the electric generators from the geomembrane.

B. Field Tensiometer: The Geomembrane Installer shall provide a tensiometer for on-site shear and peel testing of geomembrane seams. The tensiometer shall be in good working order, built to

ASTM D6693 (Type IV, 2 ipm) specifications, and accompanied by evidence of recent calibration. The tensiometer shall be motor driven and be equipped with a gauge that measures the force in unit pounds exerted between the jaws as displayed on a digital readout.

C. Vacuum Box: The Geomembrane Installer shall provide a minimum of 2 vacuum box assemblies consisting of a rigid housing, a transparent viewing window, a soft closed cell neoprene gasket attached to the bottom, a port hole or valve assembly, a vacuum gauge, a vacuum pump assembly equipped with a pressure control, a rubber pressure/vacuum hose with fittings and connections, and a soapy solution and an applicator. The equipment shall be capable of inducing and holding a minimum vacuum of 5 psi.

D. Air Pressure Test: The Geomembrane Installer shall provide the necessary air pump and fittings required to perform the GRI GM6 air pressure test on dual seams.

E. Roll Handling Equipment: The Geomembrane Installer shall provide handling equipment that is adequate and does not pose a risk to the geomembrane rolls, subject to the approval of the CQA Engineer.

PART 3 - EXECUTION

3.1 SUBGRADE EXAMINATION

A. Examine substrates, with Installer present, for compliance with requirements for soil compaction and grading; for subgrade free from angular rocks, rubble, roots, vegetation, debris, voids, protrusions, and ground water; and for other conditions affecting performance of geomembrane liner.

B. Examine anchor trench excavation, where geomembrane liner will be secured, for substrate conditions indicated above and for correct location and configuration.

C. The geomembrane subgrade shall be prepared as specified in Section 312000 and as shown on the Drawings. The subgrade shall be smooth and uniform, and free of all trash and debris, prior to installation of the geomembrane.

D. Qualified representatives of the Geomembrane Installer, Contractor, Engineer, and CQA Engineer shall observe the surface to be covered with geomembrane on each day's operations prior to placement of geomembrane.

E. The Geomembrane Installer, Contractor, Engineer, and CQA Engineer shall provide written acceptance daily for the surface to be covered by geomembrane or GCL as applicable in that day's operations. The surface shall be maintained as acceptable during geomembrane installation. A single form shall be used and signed by all parties to document acceptance each day.

F. Subgrade damaged by erosion, rutting, or other means during geomembrane deployment shall be exposed and the damage repaired. The subgrade shall then be re-approved.

G. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 GEOMEMBRANE PLACEMENT

A. No geomembrane shall be deployed and seamed until the surfaces to be covered have been approved by the Engineer and CQA Engineer. Should geomembrane material be deployed prior to Engineer's approval, it shall be at sole risk of the Geomembrane Installer and Contractor, and if the material does not meet project specifications, it shall be removed from the project at no additional cost to the Owner.

B. Geomembrane shall be installed to the required limits over the prepared compacted soil liner as shown on the Drawings and specified in this Section. Install geomembrane in anchor trenches as indicated on the Drawings.

C. No geomembrane material shall be unrolled and deployed if the material temperatures are lower than approximately 32 degrees F unless otherwise approved by the Engineer and unless special precautions are taken such as storing the rolls inside a heated enclosure providing ambient temperatures of 50 degrees F or above. The specified minimum temperature for material deployment may be adjusted by the Engineer based on recommendations by the manufacturer.

D. Geomembrane shall be placed smooth and free of wrinkles larger than approximately 4 inches high or less at the discretion of the CQA Engineer. In general, “Leister” welds or “tack” welds shall not be used to temporarily hold sheets in position, however “Leister” welds may be used to secure small patches prior to extrusion welding.

E. All geomembrane handling and installation procedures shall be performed by workers wearing shoes that will not damage the geomembrane. Only low ground pressure, rubber-tired, vehicular traffic shall be permitted to travel on the geomembrane. The maximum equipment ground pressure shall be eight pounds per square inch (psi). Conform to other written recommendations of the geomembrane manufacturer for pedestrian and vehicular traffic on the geomembrane.

F. Only the panels which will be anchored and seamed together in one day shall be deployed.

G. Sandbags shall be used as necessary to hold the geomembrane material in position during installation. Sandbags shall be sufficiently close-knit to preclude fines from working through the bags. Paper bags, lined or unlined with plastic, shall not be used. Burlap bags, if used, must be lined with plastic. Bags shall contain not less than 20 nor more than 60 pounds of sand and shall be securely closed after filling and not over-filled to prevent sand loss. Bags that are split, torn, or otherwise losing their contents shall be immediately removed from the work area and any spills immediately cleaned up.

H. Panels that become seriously damaged (torn or twisted permanently) shall be replaced. Less serious damage shall be repaired according to the requirements herein. Damaged panels, or portions of the damaged panels which have been rejected, shall be marked and their removal from the work area recorded.

I. Geomembrane shall be installed so that there will be neither tension nor wrinkles at the average expected daily ambient temperature.

J. Geomembrane shall not be allowed to “bridge over” (be pulled taut over) voids or low areas in the subgrade. Geomembrane in these areas shall be cut and patched to provide adequate material to allow the geomembrane to rest on the subgrade surface.

K. In general, seams shall be oriented with the long dimension parallel to (down) the line of the maximum slope. Where seams can only be oriented across the slope, the upper panel shall be lapped over the lower panel. The total length of field seams shall be minimized. In corners and odd shaped geometric locations, the total length of field seams shall be minimized. Seams shall not be located at low points in the subgrade unless geometry requires seaming at such locations, and if approved by CQA personnel.

L. Geomembrane panels shall be overlapped prior to seaming to whatever extent is necessary to provide a good weld. In no case shall overlaps be less than six inches for fusion welding at the time the welds are made.

M. The Geomembrane Installer shall label panels at the time of deployment. Label date of deployment, roll number, and panel number.

3.3 SEAMING PROCEDURES

A. Textured HDPE geomembrane seams shall meet or exceed the values specified in GRI-GM19, as summarized in Table 310520.10B at the end of this specification.

B. No geomembrane material shall be seamed when ambient temperatures are less than 32 degrees Fahrenheit unless the following conditions are complied with:

1. Seaming of the geomembrane at ambient temperatures below 32 degrees Fahrenheit is allowed if the Geomembrane Installer can demonstrate to the Engineer and the CQA Engineer, using pre-qualification test seams, that field seams complying with the specifications can be fabricated at sub-freezing temperatures. Consistent passing test seams are required.
2. In addition, the Geomembrane Installer shall submit to the Engineer for review, detailed procedures for seaming at low temperatures, including the following: preheating the geomembrane; and providing a tent or other device to prevent heat losses during seaming and rapid heat losses subsequent to seaming.

C. No geomembrane material shall be seamed when the ambient temperature is above 104 degrees Fahrenheit and when the sheet temperature of the material is above 122 degrees Fahrenheit (as measured by an infrared thermometer or surface thermocouple), unless otherwise approved by the Engineer.

D. Geomembrane seaming at temperatures outside the above stated temperature ranges will only be approved if: the manufacturer certifies that the seaming procedure shall not cause physical or chemical modification to the geomembrane; and an increased number of test welds is performed to determine appropriate seaming conditions when required by the CQA Engineer or Engineer. However, should the overall quality of the geomembrane decrease under such conditions, in the opinion of the Engineer, then seaming outside the allowable temperatures shall be discontinued.

E. Seaming is not allowed while precipitation is occurring unless proper precautions are made to allow the seam to be made on dry geomembrane material or the welding process is protected from rain. The surface below the geomembrane shall not be saturated or frozen.

F. Extra care shall be taken to clean and remove dirt, dust and other foreign materials from the surfaces of the geomembrane to be seamed. Surfaces shall be cleaned immediately prior to seaming.

G. Taped geomembrane edges shall remain in-place and shall be removed immediately ahead of the fusion-welding machine to keep geomembrane surface clean.

H. Seaming shall be performed using an automatic double wedge fusion welding system, equipment, and techniques. Extrusion welding shall only be used where fusion welding is not possible and as approved by the Engineer.

I. The fusion-welding apparatus shall be an automated device and shall be equipped with gauges giving applicable temperatures and pressures. Each welding machine shall be calibrated at least twice daily. The calibration procedure shall be witnessed by CQA personnel and shall be in accordance with the recommendations of the welding machine manufacturer. Certificates of calibration shall be provided to the CQA Engineer.

J. The extrusion welding apparatus shall be equipped with gauges giving the temperature in the apparatus and at the nozzle. The extruder shall be purged prior to beginning a seam until all heat-degraded extrudate has been removed from the barrel. Whenever the extruder is stopped, the barrel shall be purged of all heat degraded extrudate.

K. The Geomembrane Installer shall maintain at least one spare operable seaming apparatus of each kind on site. Equipment used for seaming shall not damage the geomembrane, and the geomembrane shall be protected from damage in areas with heavy traffic.

L. The surface of the seam edges shall be prepared as recommended by the manufacturer to provide a seam to equal or exceed the seam strength requirements in this specification. The welding process shall bond the exposed edge of the panel to the underlying geomembrane panel.

M. Fishmouths or wrinkles at the seam overlaps shall be cut along the ridge of the wrinkles back into the panel so as to affect a flat overlap. The cut fishmouths or wrinkles shall be seamed as completely as possible and shall then be patched with an oval or round patch of the same geomembrane material extending a minimum of six inches beyond the cut in all directions.

N. Seaming shall extend to the outside edges of panels to be placed in the anchor trenches.

O. The Geomembrane Installer shall label seams at the time of seaming. Label date of seaming, start time, initials of the seaming technician, and the number of the seaming unit.

3.4 PIPE PENETRATION SEALING SYSTEM

A. Provide penetration sealing system as shown on the Drawings, or as otherwise approved by the Engineer, using compatible geomembrane material, boots, stainless steel clamps, Neoprene gaskets and accessories.

B. The penetration sealing system shall be fabricated and installed to prevent leakage.

3.5 INSPECTION AND TESTING

A. Prequalification Test Seams

1. CQA personnel shall be notified when prequalification testing will be performed.
2. Welding machine calibration and test seams shall be performed by the Geomembrane Installer's personnel and observed by CQA personnel to verify that seaming conditions are adequate. Test seams shall be conducted by each seamer at the beginning of each seaming period, and as determined by CQA personnel for each welding machine used that day. Test seaming shall be performed under the same conditions and with the same equipment as production seaming. Each test seam shall be at least ten feet long for hot wedge welding and three feet long for extrusion welding with the seam centered lengthwise.
3. One-inch wide specimens shall be die-cut by the Geomembrane Installer from each opposite end and from the center of the test seam. These specimens shall be tested by the Geomembrane Installer. Five samples shall be tested for peel strength and five samples shall be test for shear strength. The tests shall be performed using a field tensiometer and shall not fail in the weld. Both welds of double wedge seams shall be tested in peel. Any failures through the seam shall be considered a failing test, regardless of the stress at failure.
4. The minimum acceptable seam strength values to be obtained for all specimens tested are those indicated in Table 313200B.
5. If a test seam fails, an additional test seam shall be immediately conducted. If the additional test seam fails, the seaming apparatus shall be rejected and not used for production seaming until the deficiencies are corrected and a successful test seam is produced.
6. CQA personnel shall observe and record testing of prequalification test specimens. Records shall be included in the Daily Field Installation Reports.

B. Non-Destructive Field Seam Testing

1. All field seams shall be non-destructively tested by the Geomembrane Installer over their full length. Each seam shall be assigned a unique number consisting of the adjacent panel numbers (for example, the seam between panels 1 and 3 would be S–1/3). The location, date, test unit, name of tester, and outcome of all non-destructive testing shall be observed and recorded by CQA personnel.
2. All defects found during testing shall be numbered and marked by CQA personnel immediately after detection. All defects found shall be repaired, retested and re-marked to indicate completion of the repair and acceptability.
3. Non-destructive testing shall be performed by the Geosynthetics Installer using vacuum boxes (in accordance with ASTM D5641), air pressure testing (in accordance with ASTM D5820), spark testing (in accordance with ASTM D6365), or other test methods approved by the Engineer. All test equipment shall be furnished by the Geomembrane Installer.
4. Non-destructive tests shall be performed by experienced personnel thoroughly familiar with the specified test methods. The Geomembrane Installer shall field demonstrate all test methods to verify to CQA personnel that the test procedures are valid.
5. Extrusion seams shall be vacuum box tested by the Geomembrane Installer according to the following methods:

    a. Equipment for testing extrusion seams shall be comprised of, but not limited to: a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge; a steel vacuum tank and pump assembly equipped with a pressure controller and pipe connections; a rubber pressure/vacuum hose with fittings and

connections; a plastic bucket; sponge or mop; and a soapy solution. The vacuum box shall be similar to the series A 100 Straight Seam Tester as supplied by the American Parts Service Company.

b. The glass for vacuum box shall be unscratched and clean, and the rubber gasket shall be firmly attached to the box.

c. The vacuum pump shall be charged, and the tank pressure adjusted to three to four pounds per square inch, gauge (psig).

d. CQA personnel shall periodically observe that a leak tight seal is created by the Geomembrane Installer. The Geomembrane Installer shall create the leak tight seal by wetting a strip of geomembrane approximately 12 inches by length of box with a soapy solution, placing the box over the wetted area and then compressing. The Geomembrane Installer shall then close the bleed valve, open the vacuum valve, maintain five psig for a period of approximately 15 seconds, and CQA personnel shall observe the geomembrane through the viewing window for the presence of soap bubbles. If no bubbles appear after 15 seconds, the area shall be considered leak tight. The box shall be moved over the next adjoining area with a minimum three inches overlap and the process repeated.

e. All areas where soap bubbles appear shall be marked and repaired, and then retested under the observation of CQA personnel.

f. CQA personnel shall observe all testing operations for uniformity and completeness and shall record results at time of testing.

g. All seams that are vacuum tested shall be marked by the Geomembrane Installer at the time of testing. Marking shall consist of the date tested, technician performing the test, and the results of the test.

6. Double Fusion seams with an enclosed space shall be air pressure tested by the Geomembrane Installer according to the following methods:

a. Equipment for testing double fusion seams shall be comprised of, but not limited to: an air pump equipped with a pressure gauge capable of generating and sustaining a pressure of 30 psig, mounted on a cushion to protect the geomembrane; a rubber hose with fittings and connections; and a manometer equipped with a sharp hollow needle, or other approved pressure feed device.

b. CQA personnel shall ensure that the Geomembrane Installer creates a leak-tight seal. The Geomembrane Installer shall perform the testing activities. Both ends of the seam to be tested shall be sealed and a needle or other approved pressure feed device inserted into the tunnel created by the double wedge fusion weld. The air pump pressure shall be adjusted, the valve closed, and the pressure stabilized for two minutes at a pressure of 28 psig (for 60-mil thickness). After the stabilization period, pressure shall be maintained for five minutes for the seam to be considered leak tight. The Geomembrane Installer shall remove the seal at the opposite end of the tested seam while CQA personnel observe the gauge. The needle or other approved pressure feed device shall be removed, and the feed hole sealed if not covered by a patch at the end of the seam. Pressure tests shall be conducted in accordance with the procedures outlined in ASTM D5820.

c. If loss of pressure exceeds three psig (for 60-mil thickness) during testing period, or pressure does not stabilize, the faulty area shall be located, repaired, and retested by the Geomembrane Installer.

d. All seams that are vacuum tested shall be marked by the Geomembrane Installer at the time of testing. Marking shall consist of the date tested, technician performing the test, test start and end times, and test start and end pressures.

7. All non-destructive field seam tests shall be observed by CQA personnel and recorded at the time of testing. Records shall be included in the Daily Field Installation Reports.

C. Data/Quality-Based Field Seam Evaluation

1. Destructive test samples shall not be collected at a prescribed frequency.
   a. Destructive test samples will be collected based on review of Geomembrane Seam Data Acquisition Welding Reports where seam temperature, speed, and pressure values are outside the defined tolerances.
   b. The CQA Engineer/personnel may elect to collect destructive test samples based on visual observation of seaming operations and/or observed seam quality.
2. Geosynthetic Installer shall supply CQA personnel the Geomembrane Seam Data Acquisition Welding Reports at the end of each working day; or at the latest the beginning of the next working day.
3. To facilitate geomembrane installation, CQA personnel must notify the Geosynthetic Installer of the intent to collect a destructive test sample within one day of receiving the Geomembrane Seam Data Acquisition Welding Reports and before the geomembrane is covered with overlying geosynthetics.
4. Should the destructive samples be collected, the Geomembrane Installer shall not be informed in advance of the sample location. In order to obtain test results prior to completion of geomembrane installation, samples shall be cut by the Geomembrane Installer as the seaming progresses.
5. CQA Engineer personnel shall mark all samples with their location and seam number at the time of sample collection. CQA Engineer personnel shall observe field testing of the samples and record the date, time, location, seam number, ambient temperatures, and pass or fail description according to ASTM D6392. A copy of the information must be attached to each sample portion. The Geomembrane Installer shall repair all holes in the geomembrane resulting from obtaining the seam samples. All patches shall be vacuum tested. If a permanent patch cannot be installed over the test location the same day of sample collection, a temporary patch shall be tack welded or hot air welded over the opening until a permanent patch can be affixed.
6. Each destructive test sample shall be 12 inches wide by 54 inches long, with the seam centered lengthwise. The sample shall be cut into three sections and distributed as follows: one 18-inch section shall be given to CQA Engineer personnel for testing; one 12-inch section retained by the Geomembrane Installer for field testing; and one 12-inch section shall be set aside for an archive sample.
7. The Geomembrane Installer shall die-cut at least three one-inch wide replicate specimens from the installer's sample for field testing. Replicate specimens will not be required for extrusion welds. The specimens shall be tested for peel strength. Both welds of dual hot-wedge seams shall be tested in peel. To be acceptable, all replicate test specimens shall meet the seam strength requirements as required in this specification. Any specimen that fails through the weld or by partial failure exceeding 50 percent of the weld shall be considered a Non-Film Tear Bond break and shall be considered a failure. Die cutting and field testing of the replicate specimens shall be performed in the presence of CQA Engineer personnel. If the field tests pass, the sample qualifies for testing by the CQA Engineer.
8. Laboratory testing coordinated by the CQA Engineer shall conform to ASTM D6392. Five replicate specimens shall be tested in peel and five replicate specimens shall be tested in shear. Both welds of dual hot-wedge seams shall be tested in peel. To be acceptable, all replicate test specimens shall meet the seam strength requirements as required in this specification.

9. If a destructive sample fails the field or laboratory destructive tests, an additional sample shall be obtained at a distance of approximately 10 feet on each side of the failed sample location. Test specimens shall be obtained, and field tested as specified in accordance with destructive field seam testing requirements. The process shall be repeated until the failed area is bounded by samples with passing test results.
10. The Geomembrane Installer shall repair the seam between the two nearest passed test locations with the failed location in between, or as directed by the CQA Engineer and/or Engineer.
11. Reports of the results of destructive field seam tests shall be prepared by the CQA Engineer and included in the Daily Field Installation Reports.

3.6 REPAIR PROCEDURES

A. Defective seams shall be repaired with a capstrip or extrusion weld over the full length of the defect. Each capstrip shall be numbered, shall be made of the same geomembrane material as for the geomembrane sheet, and shall extend a minimum of six inches beyond both sides of the seam.

B. Blisters, tears and holes in the geomembrane sheet shall be repaired with patches. Each patch shall be numbered by CQA personnel at the time the defect is identified.

C. Abrasions and other defects and damage of the geomembrane material that are not punctured through the material may be repaired using extrudate, unless otherwise directed by the Engineer or CQA Engineer.

D. Capstrips and patches shall be rounded at the corners, made of the same material as for the geomembrane sheet, and extend a minimum of six inches beyond the edge of defects.

E. Repaired areas shall be numbered and shall be measured and recorded from a known survey point to document location.

F. Verification of Repair Patches and Capstrips: Each repair shall be non-destructively tested using vacuum box testing or air testing. Tests that pass the non-destructive test shall be taken as an indication of an adequate repair. Failed tests shall be reseamed and retested until a passing test result is achieved. CQA personnel shall observe all non-destructive testing of repairs. CQA personnel shall record the number of each capstrip and patch, date, location, name of person who installed the capstrip or patch, and test outcome on a form to be submitted with the daily field installation reports.

3.7 GEOMEMBRANE ACCEPTANCE

A. The geomembrane will be accepted by the Engineer when:

1. The geomembrane is clean (brooming and washing of the geomembrane surface shall be required if the amount of surface dust or mud inhibits inspection).
2. The entire installation is finished, or an agreed upon subsection of the installation is finished.
3. All documentation of installation is completed.
4. Verification of the adequacy of all field seams and repairs, and associated testing is complete; and

5. A record survey drawing is prepared as required by this specification and is submitted to and approved by the Engineer.

B. Record Survey Drawing Requirements: Record drawing for each geomembrane layer showing panel corners, transitions in panel geometry, repair locations, destructive test locations, anchor trench breaklines, and other significant features shall be surveyed. The survey results shall be certified by a North Carolina Registered Land Surveyor.

C. Work shall not proceed with any materials which will cover geomembrane seams, capstrips and patches until laboratory test results with passing values have been received and the portion of the geomembrane has been accepted in writing by the Engineer.

D. Accepted areas of geomembrane that have not been covered within a reasonable time will require reinspection as determined by the Engineer.

E. Archive samples will be held by the Owner or Engineer until Engineer's approval of the installation and the CQA Engineer Report.

3.8 DISPOSAL OF SCRAP MATERIALS

A. At the end of each workday, all scraps of material and other debris shall be removed from the geomembrane surface.

B. On completion of installation, the Geomembrane Installer shall dispose of all trash and scrap materials off-site, remove equipment used in connection with geomembrane installation, and leave the premises in a neat and acceptable manner. No scrap material shall be allowed to remain on the geomembrane or adjacent areas.

3.9 PROTECTION

A. Protect installed geomembrane liner according to manufacturer's written instructions. Repair or replace areas of geomembrane liner damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.

B. Before placement of cover materials, inspect seams and patched areas to ensure tight, continuously bonded installation. Repair damaged geomembrane liner and seams and reinspect repaired work.

3.10 MARKERS

The Contractor shall place markers as shown on the Drawings (i.e., limit of liner). These markers shall be considered incidental to geomembrane installation.

3.11 COVER PLACEMENT

Placement of materials over geomembrane shall be performed in a manner to prevent damage to underlying geosynthetics, to minimize slippage of geomembrane on underlying surface, and to prevent excess tensile stresses in the geomembrane. Wrinkles that exceed approximately 6 inches

in height or that become crimped shall be cut, repaired and tested by the Geomembrane Installer in accordance with the requirements of this section.

Table 310520.10A - High Density Polyethylene (HDPE) Geomembrane Sheet - Textured [GRI-GM13]									
Properties	**Test Method**	**Test Value**							**Minimum Testing Frequency**
		30-mils	**40 mils**	**50 mils**	**60 mils**	**80 mils**	**100 mils**	**120 mils**	
Thickness mils (min. avg.)	D 5994	nom. (-5%)	nom. (-5%)	nom. (-5%)	nom. (-5%)	nom. (-5%)	nom. (-5%)	nom. (-5%)	per roll
● lowest individual for 8 out of 10 values		-10%	-10%	-10%	-10%	-10%	-10%	-10%	
● lowest individual for any of the 10 values		-15%	-15%	-15%	-15%	-15%	-15%	-15%	
Asperity Height mils (min. avg) *(1)*	D 7466	16 mil	16 mil	16 mil	16 mil	16 mil	16 mil	16 mil	every 2nd roll *(2)*
Density (min. avg.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties (min. avg.) *(3)*	D 6693 Type IV								20,000 lb
● yield strength		63 lb/in	84 lb/in	105 lb/in	126 lb/in	168 lb/in	210 lb/in	252 lb/in	
● break strength		45 lb/in	60 lb/in	75 lb/in	90 lb/in	120 lb/in	150 lb/in	180 lb/in	
● yield elongation		12%	12%	12%	12%	12%	12%	12%	
● break elongation		100%	100%	100%	100%	100%	100%	100%	
Tear Resistance (min. avg.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. avg.)	D 4833	45 lb	60 lb	75 lb	90 lb	120 lb	150 lb	180 lb	45,000 lb
Stress Crack Resistance *(4)*	D 5397 (App.)	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	per GRI GM10
Carbon Black Content (range)	D 4218 *(5)*	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	20,000 lb
Carbon Black Dispersion	D 5596	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	note *(6)*	45,000 lb
Oxidative Inductive Time (OIT) (min. avg.) *(7)*									200,000 lb
(a) Standard OIT **OR**	D 3895	100 min.	100 min.	100 min.	100 min.	100 min.	100 min.	100 min.	
(b) High Pressure OIT	D 5885	400 min.	400 min.	400 min.	400 min.	400 min.	400 min.	400 min.	
Oven Aging at 85°C *(7) (8)*	D 5721								per each formulation
(a) Standard OIT (min. avg.) - % retained after 90 days **OR**	D 3895	55%	55%	55%	55%	55%	55%	55%	
(b) High Pressure OIT (min. avg.) - % retained after 90 days	D 5885	80%	80%	80%	80%	80%	80%	80%	
UV Resistance *(9)*	D 7238								per each formulation
(a) Standard OIT (min. avg.) **OR**	D 3895	N. R. *(10)*	N. R. *(10)*	N. R. *(10)*	N. R. *(10)*	N. R. *(10)*	N. R. *(10)*	N. R. *(10)*	
(b) High Pressure OIT (min. avg.) - % retained after 1600 hrs *(11)*	D 5885	50%	50%	50%	50%	50%	50%	50%	

NOTES:

(1) Of 10 readings; 8 out of 10 must be ≥ 14 mils, and lowest individual reading must be ≥ 12 mils; also see Note 6

(2) Alternate the measurement side for double sided textured sheet

(3) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
Yield elongation is calculated using a a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 inches

(4) P-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials. The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(5) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(6) Carbon black dispersion (only near spherical agglomerates) for 10 different views: 9 in Categories 1 or 2 and 1 in Category 3

(7) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane

(8) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response

(9) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C

(10) Not recommended since the high temperature of the Std.-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples

(11) UV resistance is based on percent retained value regardless of the original HP-OIT value

Table 31320.10B - High Density Polyethylene (HDPE) Geomembrane Seams [GRI-GM19]							
Properties	**Test Value**						
	30-mils	**40 mils**	**50 mils**	**60 mils**	**80 mils**	**100 mils**	**120 mils**
Hot Wedge Seams *(1)*							
● shear strength *(2)*	57 lb/in	80 lb/in	100 lb/in	120 lb/in	160 lb/in	200 lb/in	240 lb/in
● shear elongation at break *(3)*	50%	50%	50%	50%	50%	50%	50%
● peel strength *(2)*	45 lb/in	60 lb/in	76 lb/in	91 lb/in	121 lb/in	151 lb/in	181 lb/in
● peel separation	25%	25%	25%	25%	25%	25%	25%
Extrusion Fillet Seams							
● shear strength *(2)*	57 lb/in	80 lb/in	100 lb/in	120 lb/in	160 lb/in	200 lb/in	240 lb/in
● shear elongation at break *(3)*	50%	50%	50%	50%	50%	50%	50%
● peel strength *(2)*	39 lb/in	52 lb/in	65 lb/in	78 lb/in	104 lb/in	130 lb/in	156 lb/in
● peel separation	25%	25%	25%	25%	25%	25%	25%

NOTES:

(1) Also for hot air and ultrasonic seaming methods

(2) Value listed for shear and peel strengths are for 4 out of 5 test specimens; the 5th specimen can be as low as 80% of the listed values

(3) Elongation measurements should be omitted for field testing

END OF SECTION 31 05 20.10